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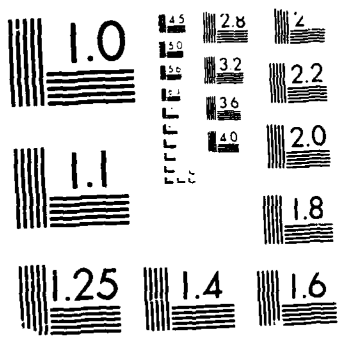

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DESIGN REQUIREMENTS FOR A DECISION SUPPORT SYSTEM FOR THE DYNAMIC RETASKING OF ELECTRONIC COMBAT ASSETS

THESIS

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Major, USAF

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THESIS

Presented to the Faculty of the School of Engineering

of the Air Force Institution of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Operations Research

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Preface

The purpose of this thesis was to investigate the establishment of initial systems requirements through the use of the storyboarding process. The system focused on in this study was a decision support system (DSS) to support the Electronic Combat Coordination Officer (ECC0) in the retasking of airborne Electronic Combat (EC) assets.

This study would not have been possible without the help of a large number of people. Chief among these is Lt Col Kemp and the office of HQ USAF/XOORS who provided both encouragement and the funds which enabled me to gather my most significant data. Equally important in my understanding of the real-world issues of tactical command and control were Lt Cols Raab and Pfeiffer of the 507 TACC, Shaw AFB. Beyond their instructions on the real world of the TACC, they were also kind enough to review my proposed decision aid and provide some very insightful feedback. Thanks also go to Maj Dave Ashing, TAWC/EWEG. His expertise provided the single most important source of information and questions concerning the problems and possibilities of the command and control of EC assets and their possible retasking. Within the arena of tactical command and control, Maj Richard Reynolds, HQ USAF/XOORC, was also very helpful in my gaining a thorough understanding of the complexities, problems, and possibilities that accompany this subject. And neither last nor least, special thanks go to Lt Col "Skip" Valusek. Both his boot and his hand, each at the right time, helped me get through one of the more interesting obstacle courses I've run in my life.

Finally, to my wife Anne my warm and loving thanks to the person who really had to go through the gauntlet. Her loving support and sane, practical advise are all the more extraordinary considering that she too was getting her AFIT O. R. Master's Degree.

Charles D. Fletcher

TABLE OF CONTENTS

List of Figures

ABSTRACT

The air commander's ability to shape and control the battle is just as critical for victory in the air as it is on the ground. The inability of the commander to control his forces in a timely manner will see them defeated by a more flexible opponent. Decision support systems (DSS) are a tool which can aid the commander by giving the overwhelming masses of information a structure for the decision process at hand and by aiding the evaluation of this information.

The problem of being inundated by data also applies to electronic combat (EC) assets. The commander's control of a these scarce resources requires a complex assessment of an enemy's air defense system and the determination of how to employ EC assets to gain the best degradation/destruction of those defenses.

To develope a DSS to aid the commander, the functions and requirements of the system must be established. The purpose of this thesis was to investigate the use of the storyboarding process as a vehicle for the establishment of systems requirements. The DSS focused on for this study was an aid to the Electronic Combat Coordination Officer (ECC0) for the dynamic retasking of airborne EC assets. The adaptive design process was used, therefore only a small core was initially proposed. The remainder of the system would follow as further requirements were generated.

The main objectives of this research were: (1) Model, through concept mapping, the probable decision process of the ECCO for the retasking of EC assets. (2) Continue the investigation into the effectiveness of paper-based storyboarding in determining system requirements. (3) Investigate the possibility of using a computer-based storyboarding process with the aim of determining the feasibility of user generation of system requirements.

The results indicate that the storyboarding process is excellent for the unambiguous communication of requirements. There is every indication that computer-based storyboarding can prove to be even more effective by taking the user one step closer to the actual system and may thereby enable the generation of system requirement by users in the field.

Copyright Acknowledgement

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DESIGN REQUIREMENTS FOR A DECISION SUPPORT SYSTEM FOR THE DYNAMIC RETASKING OF ELECTRONIC COMBAT ASSETS

I. Introduction

Mission: Electronic Combat (EC)

Operations involving the electromagnetic spectrum have long been recognized as an important adjunct to all military operations. Examples of these operations range from the radio communications countermeasures used at Port Arthur during the Russo-Japanese War of 1904 to the full range of electronic combat operations used by the Israelis in their air operations over the Baaka Valley of central Lebanon.

To support and further enhance the effective use of electronic combat operations it is the purpose of this thesis to generate an initial set of requirements for the development of an aid to support the commander in the real-time combat control of electronic combat air assets.

AFM 1-1, Basic Aerospace Doctrine of the United States Air Force, defines Electronic Combat (EC) as:

> . . . the integrated use electronic countermeasures (ECM), suppression of enemy air defenses (SEAD), and command, control, communications countermeasures (C3CM) to degrade

or destroy the enemy's ability to disrupt friendly air activity. (10:3-6,3-7)

The components of Electronic Combat are defined in JCS Publication 1, Department of Defense Dictionary of Military and Associated Terms (12:128, 356, 77). Over the past twenty years, EC operations have become more pervasive and used on a larger scale due to the increasing threat of air defense systems and its recognized contribution as a force multiplier. This has resulted in the development of dedicated air assets in the areas of Electronic Surveillance Measures (ESM), Electronic Intelligence (ELINT), Electronic Countermeasures (ECM), and Suppression of Enemy Air Defenses (SEAD). Current examples of such dedicated systems are the F-4G Wild Weasel, EF-111 Raven, EA-6B, EH-60 HAVE QUICK, RF-4 TEREC, OV-1 Mohawk, EC-130 Compass Call, and others.

Despite the recognized value and need for these systems, their tremendous costs, and the resultant scarcity of these assets, only in the last few years has there been some preliminary work done to formulate a coherent concept of the tactics for the integrated employment of EC assets, but even this has been limited to the F-4G, EC-130, and EF-111 (7). The concern over this deficiency, a subset of the more general concept of command and control, is evidenced by the 65th Air Division staff, among others, which is charged with the duty of employing EC assets within the NATO Central Region (33; 7; 6). These concerns were summarized by a team of analyst headed by Mr. Philp Cunningham of the MITRE Corporation who studied the taskings of the 65 AD and their efforts to carry these taskings out. Mr. Cunningham indicated that the 65 AD staff had voiced their concern that there was currently no defined strategy for managing the allocation of the limited EC assets to support Central Region tactical operations. He stated that the staff was further concerned that the Central Region lacked the capability to optimize the employment of the EF-111A, WILD WEASEL and COMPASS CALL (8; 15; 25).

With only the beginnings of a general employment concept emerging it is not surprising there is no formal work within the Air Force known to this writer being done on the concept of how EC forces would be retasked during a day's battle or what would be needed to accomplish retasking. Retasking is the assigning of an asset to a mission when there has been no prior planning for that possibility. This differs from an alternate mission in that an alternate mission was planned for prior to the flight as a possible mission if the primary mission was not pursued. The question of the employment and retasking of EC assets is basically a question of command and control, though electronic combat does bring its own inherently unique considerations. The official Department of Defense definition of Command and Control is:

> The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission (12:77).

It should be kept in mind that within the overall concept of command and control the concept of retasking is as important as the concept of initial employment. The importance of retasking is due to the uncertain nature of warfare and the requirement that the commander be able to adapt his battle plan to the changing battlefield to win.

> [The] primary function of command is deploying and maneuvering forces or other sources of potential power to be in the best possible position to exploit opportunities as they arise. This function can be viewed as controlling the power distribution (29:51).

The command and control process of retasking clearly reflects the application of the principles of Mass, or concentration of force, and

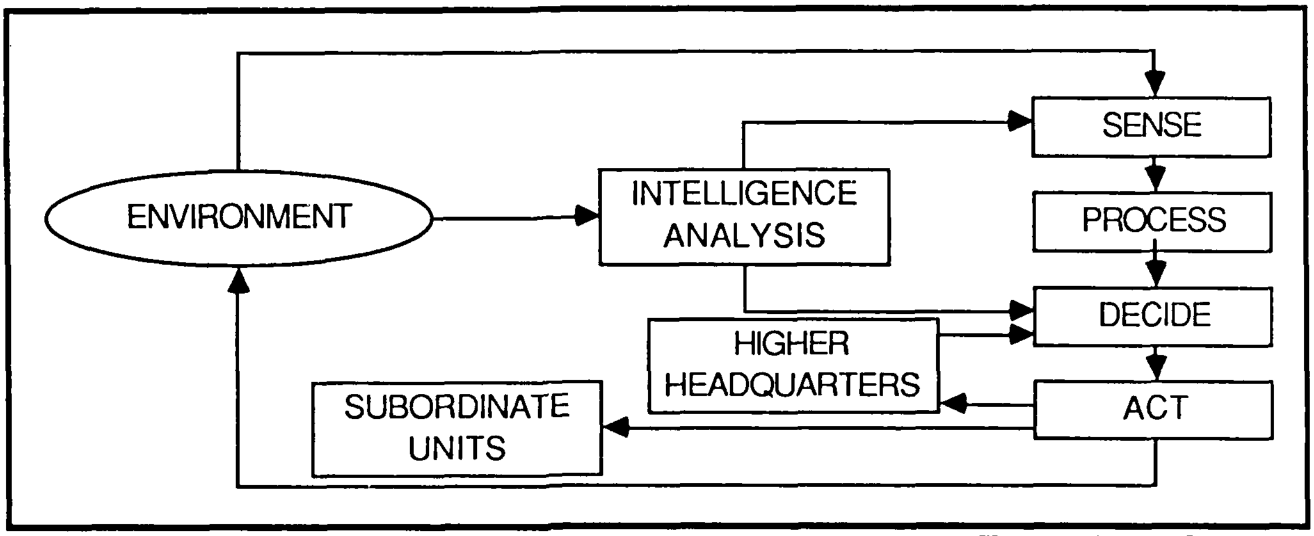
Maneuver. These principles of war are no less true in the air than they are on the ground.

Today's battlefield commander requires the assistance of an extensive staff due to the complex problems he faces. With the recognized need of employing electronic combat assets as a unified mission area there is an obvious need to advise the commander as to the best use of these forces. This requirement is being met by the establishment of the Electronic Combat Coordination Officer (ECCO) training course at the USAF Electronic Warfare School, Mather AFB (28). The ECCO must be able to advise the commander over all phases of the command and control cycle. What capabilities does the ECCO require to fulfill the role of command advisor?

Command and Control: The Required Capabilities of the Electronic Combat Coordination Officer (ECCO)

The process of command and control has been modeled extensively in the attempt gain an indepth understanding of its overall functioning. Work has been done in this area by Orr, Levis and Athans, Lawson, and others (29:26-43; 24; 29:24-25). In this study, Orr's representation will be used because it provides an adequate representation of the command and control process and basically reflects the other models.

Retasking, as explained above, is but one representation of the command and control process, requiring all its various stages. Retasking requires the same command and control functions as the initial employment of assets including the tasking of specific assets against specific missions to attain desired levels of effectiveness as measured by some evaluation system. Retasking is therefore the command and control process forced into a time compressed cycle. The lack of an ability to retask is not unique to the control of EC



Taken from Orr p.27

Figure 1. Orr's Conceptual Combat Operations Process Model

assets but afflicts all other missions and assets, further indicating that this is not a problem unique to EC but a function of command and control in general. This deficiency, from the aspect of the commander's ability to shape and modify the battle with the advent of new information, means that various EC assets, though available, would be left unused or needlessly endangered, thus violating the principles of mass, economy of force, and maneuver. These violations are to a great degree currently unavoidable due to the limited time available, lack of adequate communications capabilities, and support requirements necessary to plan and implement a new mission (33; 7; 6). The tactical aircrew employed on a combat mission on NATO's Central European front is faced with very limited time before they must be aborted or are irrecoverably committed to their initial take-off tasking and a demanding, not to say lethal, environment that commands their undivided attention. To attempt to retask an aircrew under these circumstances, even if the control agency were to read the new mission information to the crew, assuming an ECM-free environment, would prove disastrous due to the demands on the crew's time to mentally digest the new information, coordinate with others in their group, reconfigure their equipment, a myriad of other absolutely necessary requirements, and still fly the aircraft while surviving enemy assault. As a consequence of these difficulties, any modifications to today's air mission is generally limited to insignificant alteration of the basic mission or thoroughly planned and understood alternate missions. The byword of the day is "Keep it simple, stupid." This leaves today's air commander little better off than the commanders of the pre-Alexander period over 2300 years ago.

As stated above, the practice of retasking EC assets in the current command and control environment is not a viable option. To give the commander the flexibility inherent in the concept of retasking, using Orr's model as a guide, the command and control system would need to be enhanced to give the ECCO the following capabilities:

1) Monitor the progress of the battle,

2) Recognize the development of a problem,

3) Assess the impact of the problem on the overall mission,

4) Plan for a new mission in response to the problem or the development of an opportunity,

5) Develop the new aircraft mission plans,

6) Communicate and coordinate the retasking,

7) Monitor and control the implementation of the change.

Monitor the Battle's Progress.

> [The] history of command in war consists essentially of an endless quest for certainty--certainty about the state and intentions of the enemy's forces; certainty about...the environment in which war is fought, and, last but definitely not least, certainty about the state, intentions, and activities of one's own forces (45:264)

The Electronic Combat Coordination Officer must first be able to assess the status of the current battle at many levels to include the state of the various EC missions. This capability is Orr's SENSE function which has the goal of providing continuous data on the state of the environment as supplied by various sensors (29:28). This function is primarily a result of real-time intelligence which at this stage in the command and control process model is still a collection of data and not yet processed to produce a complete picture of the battle. Yet despite its raw form, this stage is like all the other stages in that without it the commander is ultimately blind and can do little to form the battle to his advantage. The ability to provide this data is continuing to take shape in the Joint STARS program, the CONSTANT SOURCE program, the E-3A AWACS program, and various other programs which are essential for gathering and distributing the varied and time-sensitive data necessary to enable the later presentation of an accurate and complete picture of the battlefield (or at least as complete as is possible in war) (13; 14). While this step is essential to the commander's ability to ascertain the status of the battlefield, as Levis and Athans point out in their review of command, control, and communications (C3) theory, this is only data and not yet information (24:3). The transformation of data into information is the process of interpreting the data and forming a human impression of its meaning. This transformation occurs in the next step of Orr's model which he entitles PROCESS.

Recognize Deviations: Genesis of a Problem. The ECCO must be able to determine that a significant change or deviation from the planned EC support mission has occurred. The determination of a significant change requires that there be an ability to compare the goal state, as set forward by the attack/support plan, and implications of the current environment. This comparison capability implies knowledge of the critical requirements and resources as determined in the original construction and tasking of the EC support package. This also implies the ability of the staff officer receiving this information to evaluate the change in relation to the commander's mission goals and priorities to determine if the change constitutes a true deviation or is it within acceptable bounds. Much of this can be done using automated computer comparison and alarming, indicating such things as the failure of a flight to make a route point within a mission-dependent time window.

The details of having the general ability to do dynamic mission assessment means having the specific capability to gather real-time knowledge on both the threat environment and the complete attack force package, including supporting EC assets. This real-time knowledge requires both secure, reliable, survivable, real-time monitoring of all aircraft and feedback from aircraft and ground support sites. This capability currently exists in an embryonic stage in the initial efforts to modernize both the USAF and NATO Tactical Air Control System (TACS) as well as the initial fieldings of the Joint Tactical Information Distribution System (JTIDS) (18; 46; 35; 20). Without these improvements to operate in the ECM environment of the future battlefield, this information will not be available and the commander will continue to be blind to the air battle.

An example of this requirement would be a detected change in the threat environment which analysis shows would result in a higher projected attrition rate. In the next step, assessment, a comparison of the originally stated requirements and limitations for the mission would show that the new attrition level is not greater than the level that was deemed unacceptable or that will significantly impact the ability of the air forces to pursue future objectives. Consequently, no mandatory action is required, though if other EC support assets become available they could be used here if this mission has a higher priority than other missions also being executed.

With respect to Orr's model, the process has now moved on to the step entitled PROCESS where the data is analyzed and put into a useful form for humans. The data can now be termed information as it can be used to further human understanding of the environment and the building of knowledge (24:3). In the context of this problem, the information will generally be presented in a graphic form such as a computer screen display of a map of the battlefield with selectable information.

Assess the Impact of the Deviation. Still within the PROCESS stage of Orr's model, the next step the ECCO must accomplish is evaluating the impact of the change on the outcome of the mission, the future capability of the EC forces, and in relation to the commander's current and future goals. The outcome of this assessment is a determination that either some action need be taken, such as implementing one of the alternatives or possibly generating a completely new tasking (retasking), or that the deviation does not impact current operations enough to require any intervention.

An attack plan is generated using several planning boundaries. The first is the commander's guidance which yields the overall objectives of the air campaign. As a result of this guidance, target lists and desired levels of target destruction are developed. An overall understanding of unacceptable campaign attrition levels is also developed by implication due to the need to pursue long-run mission objects. The second constraint is the available resources. Based on these two boundaries, the specific combination of aircraft and weapon is prepared to include a supporting cast of air refueling aircraft, EC aircraft, fighter escorts, etc. This supporting cast primarily affects the attrition level of the package but this in turn impacts the realized destruction level of the target since a lower attrition level going into the target will, in a general sense, yield a greater destructive force which can be applied to the target. Therefore, the impact of deviations in the planned mission will generally fall into these two major categories:

1) target destruction,

2) projected package attrition (34; 32).

Theoretically, even changes such as the loss of a recovery base impact the projected attrition rate. It has this kind of impact because the support required to put sorties in the air is no longer there, aircraft now fly longer legs to accomplish a mission and therefore burn more of the remaining fuel to accomplish the same mission, thus decreasing the total number of sorties that can be flown, and so on.

Of course, the deviations the ECCO would be primarily interested in would be ones that impact the lethality of the direct threat environment such as the loss of a flight of F-4G Wild Weasels or the sudden relocation of an SA-10 SAM to the middle of the ingress route. The ECCO must have the capability to analyze how these changes affect the mission, determine if the impact is significant in relation to established goals and constraints, and if there is time to implement a corrective action or only time for a GO/NO GO decision. If there is time, he must then ascertain whether a prearranged alternate plan will solve the problem or whether an entirely new plan/retasking are required. If none of the preplanned alternatives provide a solution, it falls to retasking to give the commander the flexibility to respond to the challenge or opportunity that presents itself. It is retasking that this study looks to support, as stated at the beginning of this chapter, through the generation of an initial set of requirements for a decision support system (DSS). Perhaps the major capability required of the decision aid for the viability of real-time retasking is the ability of the system to support the rapid planning and evaluation of alternate missions in the generation of a single new mission for retasking.

Planning for Real - Time Retasking. Planning for real-time retasking differs very little from that of normal planning except that what today takes several hours, looking only at a few aircraft, must be done in just a few minutes. In actuality the problem of planning the mission(s) is somewhat simplified by the fact that the planner is faced with many constraints to his flexibility and thus is left with only a few options. The assets available to accomplish the new plan are limited to the few aircraft on alert, either airborne or on the ground, which have the capabilities to meet the mission needs or those few aircraft that are left from an attack force package that was cancelled for some reason. (The first case is substituting planned spare assets to meet a loss while the latter case is that of an unexpected excess of assets in position to be used.) It is very likely that fighter-type EC assets would require air refueling prior to joining a new attack package. Therefore, fighter-type EC assets would drop from usefulness because of the delay this would probably impose on the attack force and the constraint that the retasked EC assets will not impede the attack force. Thus the planner's options are reduced still further.

Once the filtering effect of all these and other constraints are complete, as conducted by the ECCO and assisted by the aid through the use of checklists and other memory aids, then the actual generation of the new missions would be required to be supported.

Generation of Alternate Retasking Plans. The generation process of alternative missions can follow a variety of paths, anywhere from a fairly structured path to one of essentially ad hoc manipulation. In the area of retasking, we are concerned about the retasking of a limited number of supporting EC assets against a limited number of options such as NO GO or supporting one of a few missions. Consequently, the limited missions which the EC assets will be supporting and the other constraints the ECCO will be operating under will lend a ready structure to the feasible plans. None-the-less, it has been suggested that under high stress conditions "canned" templates of alternate plans can help avoid serious mistakes (17:951; 4:466). Templating could be done for a wide range of easily imagined and plausible conditions in terms of the number and types of EC assets you must retask. These templates could then be stored in an aid to be recalled as needed with all the applicable memory aids and software systems to further ease the replanning/retasking procedure.

The next consideration would be to determine in what other attack group the excess assets should be used, if the assets' original attack force had been aborted, or which group could best afford the loss of assets if a higher priority force had lost the service of some of its EC assets. This could to be done using an attrition analysis model and "what if"ing the EC support package for each group accordingly.

Of course all this would be guided by the commander's goals and guidance and the resulting target priorities. This information should be available to the ECCO (6; 34). Further planning information needed in the process would be concerning both the aircrafts' and the EC systems' capabilities, limitations, and operational considerations, such as not putting one type of EC aircraft too close to another particular type of EC aircraft. These memory aids should also extend to areas such as rules of engagement as these will definitely impact planning.

To facilitate a more complete perspective of the plans being developed and an understanding of exactly the impact the analysis models are indicating, the ECCO should have as a master working screen an overview of the geographical area with representation of the enemy Integrated Air Defense System (IADS). This geographical overview screen should have all the major characteristics of the IADS such as command connectivity, radar coverage, and missile range as selectable options (6). This logically extends to other areas as well such as representations of attack groups, the particular assets being retasked, airspace usage codes, and other major factors that impact on retasking.

Evaluation and Selection of Alternates. The evaluation of the generated alternate retasking plans should be relatively straight-forward as this would be based on accomplishing the commander's objectives while maintaining low attrition. This could be more finely and objectively measured using a multiple criteria decision making algorithm.

Mission Planning. Under normal mission planning conditions, with some variations depending on the type of weapon system, staffs above the squadron develop general plans, in response to their commander's taskings or a higher headquarters, while squadron crews do the detailed planning for each aircraft sortie.

For real-time mission planning in preparation for retasking most of what the crew normally does must be accomplished for them and then forwarded to them while they are in flight. For Electronic Combat aircraft and crews this would mean that their route and all its navigation points/times would need to be selected, calculated, prepared, and transmitted for both on-board encoding into the aircraft's navigation equipment and presentation to the crew. The mission area and/or target(s) information would also have to be prepared and loaded into the appropriate aircraft systems as well as presented to the crew for their study. This is critical for mission-configurable aircraft, such as the EC-130 and EF-111, and the F-4G Wild Weasel which adjusts its tactics depending on the surrounding terrain for tasked targets. Other information would also need similar preparation and handling such as new ingress/egress routes, call signs, iff/sif codes, and so on.

Getting this data to the crews and coordinating with all affected parties would be the final step required of the commander and his staff to affect real-time retasking of the EC assets.

Retasking: Executing the New Mission.

Communications. The new tasking must be communicated, its impact coordinated, and acknowledgement of the receipt of these changes obtained. This requires a secure, reliable, survivable, high data rate communications link, which generally excludes voice communications from much more than a warning notice of incoming information and acknowledgement of its receipt. It also requires a clear, understandable, unambiguous, high-transfer rate representation for the crew which eliminates audio or written form as each is too slow to cognitively assimilate. The most likely format is a graphics representation.

This also requires the capability for in-flight reprogramming of on-board electronic combat equipment, navigation computers and various other on-board gear that currently can only be done on the ground or requires too much of the crew's time for it to be a practical in-flight crew function during combat operations.

In-flight retasking further implies that all those who would be addressed during normal mission planning will have to be informed of the change.

Coordination. Retasking also requires that coordination be done with all other groups impacted by the new mission. This includes the new forces to be supported, air refueling tanker support, ground Air Defense Artillery (ADA), defensive air command centers, and others. Airspace management is a critical area that must be addressed. The ability to dynamically retask assets requires that coordination be done to:

1) allow the transit of former "hot" areas, such as ADA free fire areas (SHORAD is undenighably a major problem) or artillery fire space,

2) enable the rendezvous with the new attack force,

3) inform SOCs and obtain clearance,

4) nullify potential delays of the attack package,

5) minimize the adverse impact on intelligence gathering missions thereby not blinding the commander's eyes and ears,

In addition, the deconfliction of frequency is badly needed to minimize resources confliction. This is a major concern that needs to be an integral function of the planning and coordination process and which has been very little and inadequately considerations for manual operations (6; 34).

While retasking deals favorably with the commander's flexibility, it also holds a strong potential for disaster by violating the principle of Simplicity unless the forces are trained and practiced for this process.

Monitor Results. Once the retasking and coordination has been done and is being executed the cycle starts again with the commander looking for that desired opportunity to move forces at the decisive moment to the critical location.

Research Problem

The major responsibility of the ECCO would be to advise the air commander, assumed to be a NATO air commander at the AAFCE level, on a satisfactory plan for the retasking of EC assets to respond to an unexpected, and therefore unplanned for, occurrence during the execution of the air war. While this unexpected change could stem from a myriad of sources, the ECCO must be able to carry out this charter regardless of the source and be able to assess the advantages, the disadvantages, the impact on the commander objectives, and to some extent the long term impact on the EC forces of retasking. He then must be able to develop and recommend a course of action in a very time compressed environment when dealing with a very complicated, unstructured, and multivariable problem.

Research Objective

The primary objective of this research is to develop an initial set requirements for a decision support system (DSS) designed to aid the ECCO charged with advising the AAFCE commander on the real time dynamic retasking of EC assets.

Subsidiary objectives which have been identified as necessary to accomplish the overall objective are:

1. Identify the EC planning, tasking, and retasking decision processes.

2. Identify the kernel processes of the retasking process.

3. Identify the major inputs to the retasking process.

4. Identify those processes that are to be supported by a data base or a model.

5. Identify the types of information and key fields needed to build the DSS data base.

6. Identify the processes that require model simulation, what information the model is required to generate, and how levels of value or measures might be established to value the effectiveness of EC.

7. Develop the key presentations and information connectivity to enable the decision maker to assess alternate EC configurations and proposed taskings.

8. Develop an evaluation criteria and management structure for the evolutionary design of the DSS.

Scope, Limitations, and Assumptions

This study will only consider the retasking of EC assets. Further, beyond the communications needed to affect the rendezvous between the EC and attack force to be supported, it is assumed that the attack force will not be required to take any other action than it had originally planned for. Therefore, the attack force will not have to delay its FLOT penetration time, its strike times, or any other of its activities to accommodate the EC retasking.

The scope of this study is the identification of an initial set of requirements necessary to do the rapid prototyping and adaptive design of a DSS to aid the Electronic Combat Coordination Officer in advising the Allied Air Forces Central Europe (AAFCE) commander on the dynamic retasking of EC assets during mission execution.

Therefore, no system or software will be developed for this effort.

It is assumed that the intelligence and communication capabilities described earlier are in existence.

II. Methodology

Introduction

The challenge of assisting the ECCO in the real-time retasking of EC assets requires that some method be used to identify the requirements for a decision aid to this process. The nature of electronic combat is complex and fluid, changing over time with new technology as well as with the introduction of new tactics. This demanding combat environment and its associated decision process means that not all of the pertinent factors can be predetermined and thereby programed into a one-step rescheduling/ retasking system. Additionally, due to the complex and constantly changing nature of electronic combat, neither is it obvious at the beginning of an assistance program what functions this system must be able to support now or what functions it must support in the future. As a result of the complex, multidimensional, and ever-changing nature of EC, any support which is chosen to aid the ECCO must actually support the ECCO's creative decision process. In light of these requirements, a Decision Support System (DSS) was the methodology selected to aid the ECCO. Concept maps, storyboards, and feature charts were selected to identify both the initial requirements of the DSS and the subportion of the DSS to be implemented. Adaptive design supported by storyboarding was chosen for the continued identification of user requirements to enable the constructive, timely, and on-going evolution of the DSS.

Decision Support System (DSS)

What is a DSS? A decision support system is defined by Valusek as a system, either manual or automated, that supports the cognitive processes of judgement and choice. Additionally, he indicates that a DSS is characterized by a concern for decision-making effectiveness as opposed to a favored solution technique, process flexibility, an emphasis on the graphic presentations of information, enabling the decision maker to conduct "what if" sensitivity analysis, tying together both modelling and data base capabilities, incorporating subjective assessments, and an ongoing evolutionary implementation (43). Watson and Hill define a DSS as " . . . an interactive system that provides the user with easy access to decision models and data in order to support semi-structured and unstructured decision-making tasks" (47:82). They also assert that to fully qualify as a DSS the system must exhibit characteristics which are drawn from Sprague and Carlson. These characteristics include:

1) decision support systems tend to be aimed at less structured, unspecified problems;

2 they combine the use of models or other analytic techniques with traditional data management functions;

3) they focus on an interactive process that is easy to use even for people not accustomed to using computers;

4) they emphasize flexibility and adaptability to adjust to a changing environment and the decision-making approach of the user (47:82; 39:6).

Alavi and Napier also define a DSS as a system designed with the primary purpose of supporting the decision maker in the judgement process as the decision maker deals with semistructured or poorly defined problems (3:21).

An important point concerns the meaning of the terms semistructured or unstructured which play major functions in defining the type of decision process environment that a DSS should support. Sprague and Carlson use Simon's definition, calling a problem unstructured because of its novelty, the time constraints facing the decision maker, the lack of knowledge about a problem or the lack of the certainty about that knowledge, the large search space to either define the problem or identify possible solutions or both, the intuitive inputs required, or other reasons (39:94).

DSS Functional Components: DDM. Functionally, a DSS is made up of three major components, the data base management component, the model base component, and the dialog component. This is abbreviated DDM. As a system, these three components are tied together and interact with one another to provide a powerful and flexible decision support system for the decision maker. The data subsystem has the commonly accepted DBMS capabilities to manipulate data but is also made up of a richer variety of data sources and is generally a dedicated system as opposed to it being just a portion of the system's general operating system. The model subsystem allows the user the capability to easily create models, catalog and maintain a range of models, to interrelate models with appropriate linkages through the data base, and manage the model base as is done with the data base. The dialog subsystem is the interface between the user and the system. Unless the user is comfortable with this pa of the DSS he will not use any part of the DSS. The dialog compo it ould handle a variety of input devices, present data in a varie of r anners at the selection of the user, provide a variety of st or a flexible style to accommodate the user, and provide flex support for the user's knowledge base (39:28-33).

Therefore, a DSS is a system which supports the decision making process in arriving at judgements or solutions in loosely or semistructured problem environments. A DSS has various characteristics as listed above, but above all the most important is that a DSS supports the process of decision making as opposed to being the process itself.

Why DSS? Selection of the tool by which a user is assisted in solving a problem will determine to a large degree how successful that user will be in addressing the challenges that face him. Therefore, it is important that the characteristics of the tool the user is supplied with match the demands of the environment. This in turn requires that the environment be carefully analyzed to properly determine its true characteristics.

The EC retasking environment is characterized by:

1) severe time constraints,

2) high time stress levels,

3) labor intensive calculations to determine items such as the projected effectiveness of various types of electronic countermeasures against different targets,

4) an appreciation of the unpredictable synergistic effects of employing different types of EC aircraft in support of an operation and the ability to use judgement in arriving at a final employment option,

5) the need to develop and assess several different employment alternatives,

6) and an environment that can be broken into definitive parts.

This is not a comprehensive list but it does cover the major characteristics and gives an appreciation for those other characteristics that might be further listed.

When this characterization of the EC retasking environment is compared against the definition of the DSS methodology developed above, it can be seen that the DSS methodology could be used to help the ECCO solve the task of retasking EC assets. This conclusion can be further supported by using Meador and Rosenfeld's list of characteristics that mark a decision process as one which would be a good candidate for the use of a DSS.. These again parallel the characteristics of the EC retasking environment (26:164). An additional characteristic which might also be added is that the problem environment requires several different types of analytical tools to address the various aspects of the problem.

The DSS methodology was selected to aid the ECCO as it best fit the requirements as opposed to any one problem solving approach. As Schoeck stated in his thesis,

> ...choosing a specific operations research tool tends to bind the researcher, causing less than full investigation of the problem area by creating too many front-end assumptions. DSS methodology allows a researcher to explore the problem from the user output point of view, unconstrained by the need for [particular] solution techniques during the initial phases of problem definition (36:2-7).

Adaptive Design

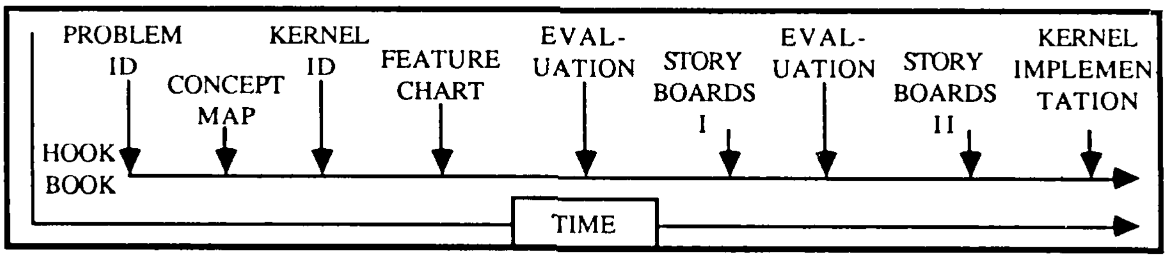
The key advantage to a DSS is its flexibility in supporting the problem solving needs of the decision maker. A design process which is as flexible as the DSS tool it is to help build is needed for the

DSS implementation. The adaptive design process fulfills this requirement. Adaptive design enables the rapid fielding of a portion of the complete aid so as to provide assistance to the user as soon as possible. It also helps to insure that system requirements are correctly determined so that the eventually complete DSS will have evolved with the necessary tools and capabilities to fulfil its theoretical potential (19).

What is adaptive design and how does it ensure proper requirements definition? Design is the process of mapping requirements into a structure. Adaptive design is an evolutionary design process based on the concept of starting small with a central aspect of the potential DSS and expanding on that starting point with the system left in place with the user (42:2). In the traditional design process all system requirements are gathered first and "frozen" so that the complete system can be constructed. The traditional design process fails to adequately capture the true system requirements due to several factors. Among these are the facts that the problem environment is rapidly changing, users are unable to provide a functional breakdown of their decision process, and users have been shown not to be aware of what they need either now or in the future. A process is needed which overcomes these hurdles. Adaptive design facilitates this by implementing a single part of the DSS and letting the user's needs, as they occur in the working environment, determine what is to be added during the DSS's stepped expansion. This dynamic design process enables the DSS to meet the user's evolving needs (9:19). The question of how to select the initial core, or kernel, of the DSS to implement first and the basic configuration of the system are at the center of this research and will be discussed below.

The actual adaptive design process incorporates the traditional four development steps (i. e., requirements analysis, design, development, implementation) by compressing them into a single step which is repeated rapidly over the period of weeks as opposed to years as is typical of the traditional approach. This is possible because only a small part of the DSS is selected by the user and builder/designer to be initially implemented. During each cycle the system is evaluated, modified, and incrementally expanded. After several repetitions of the cycle the system will become relatively stable and the next major subsystem is tackled. As mentioned earlier, the system will never be completely stable. This is primarily the result of a purposeful strategy of the user and designer to accommodate flexibility and changes in the decision process, the environment, improving technology, and various other reasons (38:16-17; 39:15).

The initial requirement for the DSS to be constructed, the initial subsystem to be implemented, and the on-going and evolving system requirements are all determined in the process illustrated in Figure 2 which illustrates the front-end development of a DSS.



Adapted from Schoeck p.3-4

Figure 2. Requirements Determination During DSS Development

After the initial determination that a problem exists and the user needs some assistance in a decision process, concept mapping is used to identify the structure of the decision process and what part of that process might be aided by a DSS. Feature charts show the information connectivity of the process while storyboards are used iteratively to flesh out the detailed requirements of the DSS prior to full implementation which by definition irrevocably commits the limited resources of the organization. Each of these tools will be discussed further below. This process continues through the evaluation of the system, determination of further requirements using storyboarding, and implementation of the approved storyboards as functioning capabilities. The genesis for this evolution and expansion is the "hook book." The hook book is a repository of ideas for the desired/needed enhancements to the DSS. These are collected throughout the design/development process and thereafter as the system is in use (42:10). Throughout this process the system is able to respond to the long term needs of the user by adapting to the problem space (38:17). As such, the adaptive design process forces the user and designer/builder to continually assess the adequacy of the DSS in supporting the needs of the user and how it might evolve to meet those needs. This continuing analysis enables the user to more truly determine the basic, on-going requirements of the DSS and overcome requirements determination problems like recency (recency is remembering first the last event, in this case a problem, that was added to memory regardless of its true priority of importance) (39:16; 2:583).

Concept Maps

Concept mapping was used to identify and select that part of the ECCO's retasking decision process that was to be aided first by the decision support system. A concept map is a graphic depiction of the hierarchial interrelationships among concepts of some given subject. It uses nodes to represent the concepts which are elements of the overall subject and descriptive linking words on connecting arcs to show their interrelations (27:44-85). In this case the subject of interest was the decision process of the ECCO when faced with the retasking of EC assets (Examples of these are in Appendix A).

Concept mapping aids the designer/builder in the determination of what subportion of the decision process to aid by providing a quick bounding of the problem space and a general understanding of a problem's interrelated factors as well as their structure. McFarren concludes in his thesis that " . . . concept maps created by the expert capture the key concepts of the problem and/or the elements of the decision process used by the expert" (27:68). This mapping thereby helps the designer/builder in identifying the key concepts, the crucial nodes of the hierarchy, and consequently aids in selecting a part of the decision process to assisted in building the DSS. This part or element of the decision process which is selected for aiding is called the kernel.

ROMC: The DSS Conceptual Framework

After the problem has been bounded through the use of concept mapping and it has been determined which kernel is to be implemented, the question of designing the structure of the DSS still remains. Sprague and Carlson provide the framework that was used in this research which is known as ROMC and stands for Representations, Operations, Memory aids, and Control mechanisms. This framework has proven to be useful in helping the decision maker more easily define the decision process by requiring the concrete description of the tools needed to support the decision process. A more focused definition of the decision process results in an easier identification of the requirements for the DSS. As this framework clarifies the system's requirements, it in turn markedly aids the development of system's initial design while its continued use also aids the DSS's evolution (39:96-101; 43).

ROMC is a design framework that is independent of any particular decision process or system that it has been used on in the past. It is designed to identify the required capabilities of a DSS. The ROMC components are as follows:

REPRESENTATIONS: Representations are the context in which the decision maker interprets output from the DSS and invokes operations of the system. The importance of this part of the framework is reflected in Sprague and Carlson's following observation:

> . . . decision makers have trouble describing a decision-making process, but they do seem to rely on conceptualizations, such as pictures or charts, when making or explaining a decision . . . (39:98)

This reflects the fact that any decision-making process occurs using a conceptualization of the information. The form the conceptualization may be mental, a picture, a map, graph paper, or any number of other forms.

OPERATIONS: Operations are those activities which support the decision process. These are such activities as gathering data, analyzing data, forecasting results given a particular set of stating data, comparing results against some criteria or other results from a different model, putting the data or results into a presentation format, preparing reports, and so on. Changing the terms of Simon's paradigm, intelligence, design, and choice, as seen in the figure below and using it to help classify the operations, it can be seen how these operations support the decision process in Figure 3 below.

MEMORY AIDS: Memory aids are made up of both representations and operations to support the user in the decision process and in the use of the DSS. These aids may take the form of:

1) data files compiled by the user as a result of a model the user constructed and ran,

2) an automated check list that comes up whenever a given process is initiated,

PROBLEM FORMULATION
- Gather data
- Diagnose problem
- Validate data

ALTERNATIVE GENERATION & EVALUATION
- Gather data
- Model and analyize alternatives
- Sort data

CHOICE
- Generate statics on alternatives
- Choose among alternative
- Explain choice

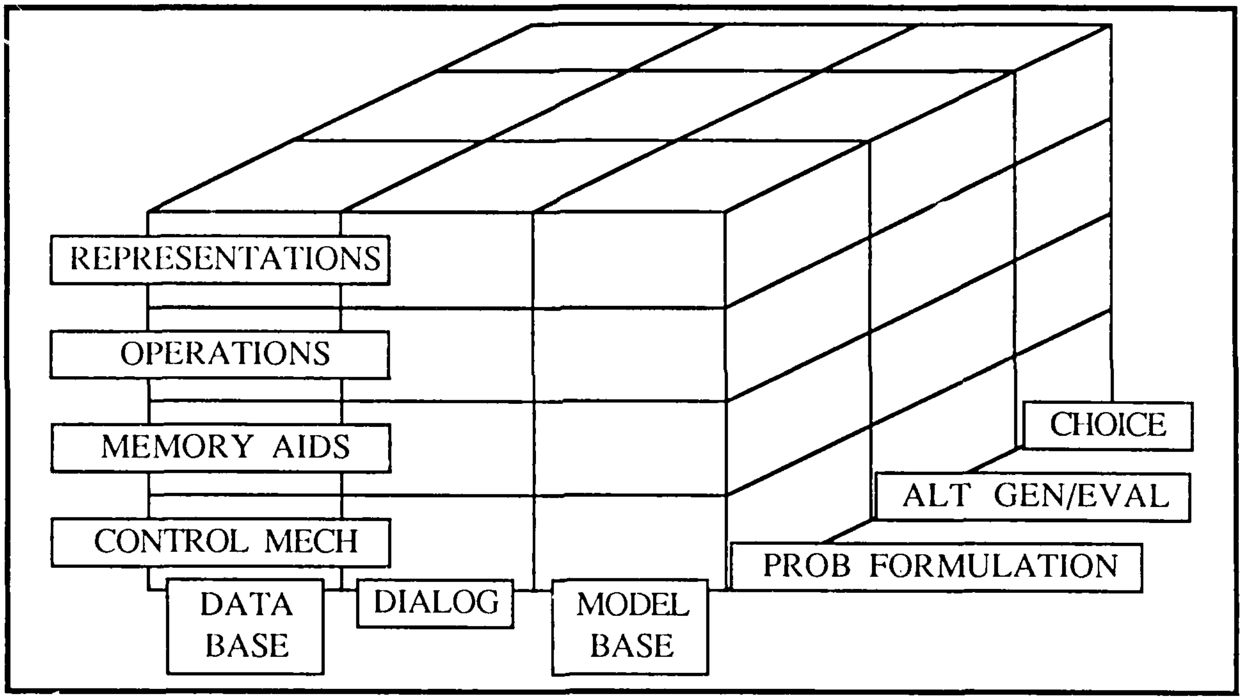
Adap'ed from Sprague and Carlson p. 104

Figure 3. General Decision-Making Operations for Simon's Paradigm

3) a computer notepad to store notes for later reference, and so on.

CONTROL MECHANISMS: The DSS control mechanisms enable the user to use the representations, operations, and memory aid with minimal frustration while proceeding through the decision process. As can be seen this portion of the ROMC framework has a very direct link to the Dialog part of the DSS's three major functional components. As such, the control mechanisms are crucial to the success of the DSS because they encourage or discourage the decision maker to make direct use of the complete DSS in working through a decision. These mechanisms generally take the form of the system software controls, such as the menus or function keys, or the explanation/training capability of the system. These functions enable the implementation of the tools of the DSS, altering or combining the basic tools, etc., to aid the user through the decision process.

As indicated in above, there is an interrelation among the functional components of the DSS, the DDM, and the ROMC framework. An efficient clarification of this interrelationship is a cube developed by Valusek (41; 43) shown in Figure 4, which also includes the relation of Simon's modified paradigm.



Taken from Valusek (58)

Figure 4. Interrelation Between ROMC, DDM, and Simon's Paradigm

Storyboards and Feature Charts

Storyboards and Their Use in the Design Process.

Storyboards and the process of storyboarding is borrowed from the animation and advertising industries where they are used to present proposed project scenes or displays. Storyboards for computer based systems are a sequence of displays depicting the screen presentations.

These screen presentations are of specific functions for a proposed DSS (5:3; 43). The depictions support the adaptive design process by enabling an inexpensive preview of the DSS as the user will see it and allowing for quick and easy modifications to meet user's needs.

> Storyboards are "live" tools. They are designed to verify requirements definitions, help "size" systems design specifications, and serve as compasses to software engineers. They are dynamic, subject to user and technical review. They are also intended to consume relatively little of the systems design and development budget, while protecting the same budget from false starts, inaccurate requirements definitions, and over-eager programmers (5:4).

Thus, storyboarding is a vehicle for requirements generation, enabling the designer to easily and cheaply zero in on the actual details of the kernel DSS configuration such as controls, visual displays, inputs, outputs, processes to be support, as well as data structures and system peripherals. This is significant as these requirements may not be initially evident in the command and control arena due to the lack of a comprehensive command and control theory and the unstructured and/or dynamic environment of the decision maker (43; 9:7).

The storyboard process itself is straightforward. After the kernel has been determined using concept mapping, the designer/design team and the user(s) meet to develop a rough concept of the system. Next, an initial set of storyboards are developed to act as a strawman. This set of storyboards is an anchor on which to elaborate, build, change, and expand. All members of the team, especially the users, must review these storyboards and revise them as each member deems necessary by actually redoing the displays. When a rough consensus emerges the storyboards are converted into software. As the storyboards are to eventually become a computer display, the best approach is to construct and display the storyboards on the system to eventually support the working DSS (5:5; 43).

Feature Charts and Their Use in the Design Process. A feature chart, which is a synthesis of the ROMC model, is a symbolic depiction of the connectivity of the representations with which a user interacts, the possible paths from one to another, and how to navigate to a desired feature. As such, feature charts produced by the designer/builder serve two purposes. First, they serve the purpose of system analysis in that the tasks the DSS is to perform are clearly identified. Second, they serve as a very clear communications link between the user and the designer, depicting the designer's impression of the functions of the DSS as necessary to support the user's decision process (37). As a consequence of these purposes, feature charts can also help to verify user needs and system requirements.

In addition to the above, feature charts also lend perspective and dynamics to the storyboarding process. When used in concert with storyboards, feature charts show the interconnection between various displays, thereby giving a "you-are-here" perspective overview of the system with reference to the storyboard being looked at (43). Further, when using the paper-based storyboarding process feature charts can also serve to give the user a better understanding of the dynamics and flexibility of the DSS. This latter benefit may not be significant when the storyboards are computer based.

III. Application of Methodology

Introduction

Chapter Three discusses the use of the DSS methodology to address the problem of aiding the ECCO in the process of real-time retasking of EC assets. While no system was actually fielded, initial problem identification and requirements definition using the DSS adaptive design process were explored. Additionally, the problem of insuring continued evolution of the DSS once the kernel was fielded was also considered. As such, the initial step was an identification and bounding of the problem to be addressed, in this case that of real-time retasking of Electronic Combat assets in a conventional war fighting environment such as that of NATO's Central front. Once the scope of the problem was roughly defined, the second step was to select that specific portion of the problem, the kernel, which was to be implemented. These two steps are discussed in the following section on Concept Maps and Kernel Selection. The third step was to determine the required capabilities of the kernel. This was accomplished using the Storyboarding process, guided by Sprague and Carlson's Representations, Operations, Memory Aids, and Control mechanisms (ROMC) framework. In the event that a system's capabilities were determined and the kernel was fielded, the next step would be to insure the evolution of the kernel to both meet evolving user needs and to set the stage for the expansion of the aid toward a complete system through the addition of other kernels. This is in many ways very similar to the initial requirements development and is discussed in the section on Adaptive Design and Continuing Requirements Generation. The results of these processes are discussed in Chapter Four.

Concept Maps and Kernel Selection

The major hurdle to the first steps of defining and bounding the problem is that the process of real-time retasking of EC assets is a function that is currently executed on an ad hoc basis. It is not a capability that is currently planned for and exercised as a normal function across all mission areas as controlled by the USAF Tactical Air Control System (TACS) (11; 34). The activity that comes closest to practicing some real-time retasking is in the mission area of Close Air Support (CAS). Here too, true retasking is more correctly described as an ad hoc function. The failure to accomplish retasking seems to be due primarily to the lack of the capability to quickly and accurately assess the impact of mission changes, the lack of an ability to rapidly and securely communicate the necessary information to the forces, the inability of the aircrews to digest and use the information if it were possible to obtain it, and the inability to reconfigure on-board mission equipment/munitions in flight to meet the new threat. In turn, these shortcomings are a result of not planning for retasking and therefore not acquiring this capability.

Retasking Planning. The task of real-time retasking is essentially one of planning which has been forced into a much shorter time frame than that of the normal EC mission planning cycle. Retasking, though, is still further removed from initial planning in that the range, or the feasible region, of possible new plans which can be developed is vastly restricted by the current environment. This greatly simplifies the generation of alternatives because many of the mission variables now have set values and limits. At this point, the mission factors that are of interest are those factors that have changed and thereby caused the mission to fall into the retasking category. These factors now become the variables within the replanning process such as an unexpected increase in the threat environment due to the concentration of mobile SAM/AAA assets in conjunction with an enemy offensive thrust (44).

Concept Maps. Because real-time EC retasking is not a normal Tactical Air Control Center (TACC) function, there does not exist an expert in this area. On the other hand, there are experts in the areas of EC mission planning and the employment of Close Air Support assets. Due to the real-time nature of the latter area, it is often a real-time retasking process. These experts exist in the combat plans and combat operations sections, respectively, of a TACC. Due to the lack of an actual expert in the field of real-time EC retasking, experts in the associated fields were consulted for the definition and boundaries of the problem, the functions necessary to accomplish retasking, and the necessary capabilities of a decision aid to support the ECCO in pursuing real-time EC retasking. Additionally, various other experienced personnel with operational backgrounds in command and control, operational planning, and electronic combat were also consulted. From a composite of this information a concept map of the problem domain was drawn up (See Appendix A).

The use of the resulting concept map allowed the structuring of the problem, giving it scope and bounds, identifying the major functions and activities which are the different kernels of the process, and identifying the interconnectivity of the information and processes. This latter area enables the later generation of feature charts which explicitly show the inter-connectivity of processes of the proposed system.

This composite concept map showed that the subject area of EC C3I broke down into four major subcomponents: Phases of EC C3I, Real-Time Assessment Ability, Planning and Decision Making, and Execution. Of these areas, the concept map confirmed the intuitively apparent interrelationship between the Planning and Decision Making process and Real-Time Assessment Ability. This strong interconnection points up the fact that to construct a completely integrated DSS which supports the ECCO in replanning requires that the DSS eventually support the ability to assess the current environment. These two major areas were broken down even further in the concept mapping process to determine the supporting processes.

The ability to do real-time assessment of the environment, as determined by the concept map, is the result of information from three major subareas: the enemy IADS (Integrated Air Defense System) Threat, Blue Assets Status, and Mission Targets. The ability to do planning and support decision making was determined to be a function of the commander's objectives/missions, the principles of war, available EC and support assets, the generation of EC support plan(s), and the ability to evaluate alternate plans and choose the final plan for implementation. These eight subareas, as can be seen in Appendix A, in turn were divided into finer and more specific functions, information requirements, principles, etc., until a thorough understanding was developed of the general make up of the decision process to be supported and its bounds. If there had existed an expert from which this concept map was derived, the next step would have been to continue developing maps over time until these maps showed a stability. Once this was accomplish then the next process would be the selection of one of the subproblems, called a kernel, as the starting point for implementation. As there is no expert, the composite concept map was assumed to be stable, though possibly not exhaustive. Given that the map was stable, the next step was the selection of the kernel as the starting point and focus of further development work.

Out of the many elements needed to support the ECCO with a functional and useful DSS, how does the designer/builder determine where to start? It has been suggested that starting with the function that is the most time consuming and mundane is the place to begin (21;3-6, 3-7). Another starting point might be to select some central but well defined subproblem so as to engender an understanding and confidence in the process as well as providing a useful element to users. Working with the user on a subproblem that is well understood should enable an easier identification of the system's processes and better enable the user to communicate his/her needs for that particular area of the system. Once confident that the process is feasible and the product of use, the user will be more willing to attempt tougher parts of the system such as those parts that are less well understood and thus harder to communicate and implement. It was the latter philosophy that guided the selection of a kernel to implement for the ECCO's DSS.

The ability to assess the SAM/AAA component of the IADS threat is one such central and well-defined subarea. Given the central importance and understanding of this area, it was selected as the starting point, the kernel, for implementing the DSS. Once this decision was made, the concept maps were used to get a more complete understanding of the general types of information needed to support this assessment capability. The next step was to present the needed information in such a manner so as to enable the user to quickly and flexibly determine the state of the enemy IADS, thereby enabling the ECCO to make more rapid and accurate decisions about the impact the IADS will have on plans being developed. Storyboards and feature charts were used to determine the user's specific requirements of the system's presentations, functions, modeling capability, user support needs, and other capabilities of the DSS.

Storyboard and Feature Charts

The next phase in developing the DSS using an adaptive design approach was the development of storyboards, using Sprague and Carlson's ROMC (Representations, Operations, Memory Aids, and Control mechanisms) approach, to determine system requirements. Storyboards, as discussed in Chapter Two, are examples of the computer screens, generally nonfunctional, the user would see and use in the actual system. These example screens present the representations, operations, memory aids, and control aids that the designer has developed based on input from at least the concept maps and users. The use of storyboards allows the user to get a concrete feel for the construction and adequacy of the system being proposed. Further, it gives the user an anchor or concrete example to use as a point of reference from which to indicate whether the proposed system meets his/her operational needs and how the system must be changed so that the DSS will meet operational needs.

The adaptive design of a DSS, or any system, is a highly interactive process between the user and designer/builder. As mentioned earlier, there is currently no real expert and/or user in the area of the real-time retasking of EC assets though expertise in the component areas does exist in a TACC. As such, the personnel of the 507th Tactical Air Control Center, Shaw AFB, SC, represented the closest incarnation to an EC battle management expert. Lt Col Pfeiffer, Chief of Combat Operations, and Lt Col Raab, Chief of Combat Plans, agreed to act as the "user" for this effort and review the system storyboards that had been developed. Information on the storyboards was exchanged using paper copies sent through the US Postal Service. This was due to the distances involved and lack of the requisite hardware being available to the 507 TACC to run the computer-based storyboard presentation developed for this research. Only one exchange was possible primarily due to time constraints on this effort. Results of this exchange are discussed in Chapter Four.

Adaptive Design and Continuing Requirements Generation. The adaptive design process is a dynamic, on-going effort aimed at allowing a system to evolve from a small initial portion of the system to the ultimately complete system. Along the way established parts of the system should also adapt and evolve to meet the needs of the user in solving problems in a changing environment. To accomplish these goals there must be requirements generation to specifically identify how the system needs to change. To meet this need, storyboarding was used for requirements generation and Apple

Computer's HyperCard program was used to explore both the possibility of an all-encompassing development environment and enhanced requirements generation through storyboarding. The latter area was hypothesized as being possible if the user were provided with a presentation method closer to the real DSS and the user was supplied with a system which allowed the easy development of storyboard by the user, thus not losing/distorting requirements through communications problems.

The Use of HyperCard. Currently, most storyboarding is thought of as a paper process where the computer screen display is rendered on a paper product. This static display is then presented to the user with an attached explanation of the screen's functions.

In an ideal world, a user would be handed a completed system, work with the system for a period of time long enough to identify desired changes, the system would be modified as requested, and the system would then be returned to the user to begin the process all over again until the system became relatively stable. The system would be stable in the sense that it would require only minor changes over time with infrequent major modifications. It would and can never be frozen or become static as the system would soon not meet the user's needs in a rapidly changing and complex environment such as combat command and control.

Functional Display. In an attempt to reach this ideal state, this research was conducted using Apple Computer's HyperCard. HyperCard enabled the placing of static example screens on individual graphics data fields called Cards. Each of these cards is a data field in a graphics relational data base. A data file of these cards is called a Stack. Within the stack it is possible to "link" the screen presentations as they would occur in an actual system. This linkage is based on the selection of command menu items available on a particular example screen. Once an example menu item is selected the linked field, or card, is brought up for the viewer as if the operational system had carried out the function and modified the presentation. Therefore, HyperCard was used to allow a dynamic presentation, or functional display, of the proposed system, giving the user a more realistic feel for the functioning of the proposed system.

Combined Storyboard and Feature Chart. Additionally, HyperCard-based storyboarding has the advantage of automatically and simultaneously incorporating some of the aspects of feature charting into the storyboards. While a HyperCard-based system does not give an overview of the interconnectivity of the system's proposed functions, it functionally demonstrates the interconnectivity of the features. Unfortunately, as mentioned above, due to equipment limitations the 507 TACC was unable to evaluate the prepared HyperCard-based storyboards and only reviewed paper hardcopy printouts of the example screens.

Software-based Statement of Need (SON). Another advantage that the storyboarding process has to offer when run under a HyperCard-based or similar environment is the capability to generate a software-based statement of need (SON). Given a library of icons and screen displays, the user originated generation of storyboards with only the assistance of a DSS designer becomes possible. Once these storyboards have been generated and linked by the user as he/she desires, they can then be modified and reevaluated over several iterations until the storyboards stabilize. This stabilized product then becomes a software-based SON. Further research needs to be done in this area as it holds promise for easing and speeding up the generation of an information engineering SON (41).

A Support Environment. HyperCard offered the additional advantage that external programs can be called to support features on the storyboards. Short of actual real-time display presentations of the environment, this capability allows the user and/or the builder/designer of this environment to completely assemble a near operational system from scratch. The process of generating the displays for this research was greatly simplified by having an environment capable of supporting the entire systems design/development process. An enhanced environment capable of supporting this process in an actual operational environment would have enabled the users to more rapidly iterate through the adaptive design process, test the operationally effectiveness of the designed system as each part of the DSS grew before proceeding too far on a wrong path, and provide an instant credibility for the system because it would have grown up with the using unit based on that unit's way of doing business.

Evaluation Criteria

The establishment of criteria to evaluate a DSS is essential to ensure that the system continues to progress toward the established goals which represent the stated needs of the user(s). Without an evaluation framework and criteria there is a tendency for the development effort to not maintain a continued focus on the initially desired capability of the system, an inability to accurately determine priorities, to determine the worthwhile problems to solve now and which to leave until later, and other problems.

The criteria developed for this effort were originated under a framework that represents the fusion of work offered by Sprague and Carlson, Building Effective Decision Support Systems, and Sweet, Metersky, and Sovereign, Command and Control Evaluation Workshop. A matrix was constructed of Sprague and Carlson's four "P"s, Productivity measures, Process measures, Perception measures, Product measures, and Sweet et al.'s three "M"s, Measures of Performance, Measures of Effectiveness, Measures of Force Effectiveness, and specific criteria were developed for each of the twelve resulting cells. This was done because the four P's provide a framework primarily focusing on the DSS and its impact on the organization while the three M's are designed to ensure the development of criteria which carry a different perspective, moving from the technical aspects of the DSS to the environment beyond the using organization's forces (41; 44).

In Sprague and Carlson's measures;

1) Productivity measures are used to evaluate the impact of the DSS on decisions.

2) Process measures are used to evaluate the impact of the DSS on decision making.

3) Perception measures are used to evaluate the impact of the DSS on decision makers.

4) Product measures are used to evaluate the technical merit of the DSS. (39:159)

To define the measures put forward by Sweet et al.:

1) Measures of Performance (MOP) are evaluated inside the boundary of the C^2 system and measure attributes of system behavior such as S/N ratios and error rates.

2) Measures of Effectiveness (MOE) are evaluated outside the boundary of the C^2 system and measure how the system performs its functions within an operational environment. Examples of these are reaction time, probability of detection, and number of targets nominated.

3) Measures of Force Effectiveness (MOFE) are evaluated outside the boundary of the force being controlled and measure how a C^2 system and the force, of which it is a part, performs mission or contributes to the outcome of the battle (40:2-4, 2-7).

As depicted in Figure 5, this yields a framework for the construction of criteria that cover all aspects of the DSS from a full range of perspectives. An example of this is how to interpret the Productivity row:

- Matrix cell 1 concerns criteria which measure how internal system performance impacts the decisions being made.

- Matrix cell 5 concerns criteria which measure how the system performs within a specific environment impacts the decisions being made.

- Matrix cell 9 concerns criteria which measure how the mission performance of the system/force combination impacts the decisions being made.

	MOP	MOE	MOFE
Productivity	1	5	9
Process	2	6	10
Perception	3	7	11
Product	4	8	12

Figure 5. Evaluation Matrix

The actual criteria which could be used are as follows:

1) Matrix cell 1 concerns criteria which measure how internal system performance impacts the decisions being made.

2) Matrix cell 2 concerns criteria which measure how internal system performance impacts the decisions making process.

3) Matrix cell 3 concerns criteria which measure how internal system performance impacts the decision maker.

4) Matrix cell 4 concerns criteria which measure internal system performance.

5) Matrix cell 5 concerns criteria which measure how system performance within a specific environment impacts the decisions being made.

6) Matrix cell 6 concerns criteria which measure how system performance within a specific environment impacts the decisions making process.

7) Matrix cell 7 concerns criteria which measure how system performance within a specific environment impacts the decision maker.

8) Matrix cell 8 concerns criteria which measure technical merit within a specific environment.

9) Matrix cell 9 concerns criteria which measure how the mission performance of the system/force combination impacts the decisions being made.

10) Matrix cell 10 concerns criteria which measure how the mission performance of the system/force combination impacts the decisions making process.

11 Matrix cell 11 concerns criteria which measure how the mission performance of the system/force combination impacts the decision maker.

12) Matrix cell 12 concerns criteria which measure how system technical merits impact the mission performance of the system/force.

The storyboard presentation of the ECCO DSS which was developed as a result of the application of these above tools was sent to the 507 TACC for comment. The 507 TACC was only able to evaluate and comment on the paper storyboard because they did not have a Macintosh II or Macintosh SE to run the HyperCard-based presentation. The results stemming from their observations and work done by the author are presented in Chapter Four which follows.

IV. Results, Conclusions, and Recommendations

Introduction

As stated in Chapter One, the focus of this study was the generation of the initial requirements for a decision support system. Chapter Four therefore begins with a presentation of the results of working with a potential user of the ECCO DSS, the 507 TACC, to develop the system's initial requirements through the use of the decision support system methodology supported by the adaptive design approach. This is followed in the second section by a discussion of the current thoughts of several users concerning the use of a DSS in the TACC and where the biggest payoff may be for command aiding. The final section covers conclusions and recommendations. Thus, the major divisions of this chapter are:

1) Results of User Reaction,

2) Is An EC Retasking DSS Needed by the TACC?

3) Conclusions and Recommendations,

a) Organizational Impact: Observations and Recommendations,

b) ECCO DSS: Conclusions and Recommendations,

c) The Storyboard Process and Requirements Generation.

Results of User Reaction

The 507th Tactical Air Control Center (TACC) as User. The 507th Tactical Air Control Center (TACC) acted as the user for the purpose of iteratively critiquing the ECCO DSS in line with the adaptive design process. There is currently no organization that can act as a true user because there is no actual retasking of EC assets at this time. The closest entity to a retasking agency is the TACC because it does both the planning for the air mission for a large area and/or force coverage as well as the real-time control of air assets during mission execution. Also, the TACC does the active tasking of CAS assets during the battle which at this time is the closest activity to true dynamic retasking. The Airborne Command and Control Center (ABCCC) is also involved in the real-time execution of the air battle but does not, to the limited knowledge of the author, become as heavily involved in the original campaign planning as the TACC. Therefore, the TACC was selected over the ABCCC for its overall greater in-depth knowledge of the full planning and execution cycle.

507 TACC Comments on the ECCO DSS. The personnel of the 507th Tactical Air Control Center did not feel that there were any serious deficiencies or errors in the proposed ECCO DSS. This appears to be due to the use of the concept maps as a front-end analysis to determine the basic makeup of the retasking process and therefore the required capabilities of the ECCO DSS. In the initial phases of this study, during which the tactical air control process was being researched and the concept maps to describe the process were developed, there was not an opportunity to interview members of the 507 TACC. Therefore, former tactical air control center personnel currently assigned to the Tactical Air Warfare Center (TAWC), HQ USAF, and HQ ESD were interviewed. The planners and controllers of the 507 TACC were in agreement with the developed concept maps with one exception that did not impact this study (see Appendix A, pg. 66). Additionally, while personnel of the 507 TACC

is not currently viable and would require major enhancements to both the tactical air control system (TACS) and to mission aircraft before it would be possible. Chief among these requirements is the availability of secure, jam resistant communications for both voice and data. The JTIDS system appears to address this issue to a large degree by allowing a wide range of users to "talk" on the same secure, jam resistant net. Coordination is the second area of concern. JTIDS also helps alleviate the coordination problem that must be overcome both in flight, between supporting and supported air forces, and with ground organizations such as the US Army's Air Defense Artillery (ADA) units. The availability of real-time fused intelligence is the third area which would require major enhancements before the dynamic retasking of EC assets is a viable option to the commander. The major enhancements are currently being addressed Included with this information on enemy systems is a requirement for information on friendly systems. This double issue supports the fourth area required for retasking which is the ability to determine that there is in fact a problem that must be addressed and can only be solved through retasking. Upon determining the need for retasking, the next capability that is required is the generation and evaluation of alternative plans. The development of a decision support system attempts to provide a vehicle to solve this problem with areas for continued research outlined in Appendix C. Finally, to enable the execution of retasking, better air space management and control is required, a means to prepare and present information to the in-flight crews is critical, and the issue of the in-flight reconfiguration of EC systems and ordinance must be solved. This is the supporting infrastructure that must be present before the dynamic retasking of EC assets is possible.

System Supportability in the Field. The TACC is a field unit that must be able to move quickly and operate from austere locations to insure its survival in a scenario such as a NATO-Warsaw Pact war. Fielding the current generation of decision aids would result in systems in the TACC which are generally tough to support, move, power, and hide. Also, there is a concern that to support all the jobs of the TACC would result in a TACC overwhelmed with "black boxes." These are areas currently being addressed by HQ TAC/DR/DO, HQ ESD/TCR, RADC, and others.

Human Processing Time Constraints. The greatest concern as to the viability of retasking lies not with the machines but with the humans that control them, both in the air and on the ground. The distances within the European theater, west to east, or the Korean theater, south to north, are very small in terms of both physical distance and, more importantly, time. It is a real concern that retasking will not be possible even with all aspects of the supporting infrastructure described above because of the small time frame involved. Within this small time frame there must be time for the ECCO to perceive a problem and find a solution, time for the commander to understand and approve the retasking, time to get the word out to the effected units and forces, and time for the crews to digest the information and act on it. These human time requirements put the process of retasking in doubt to many and certainly constrain when retasking might be a viable option.

The Aiding Payoff: Greatest For Air Campaign. In light of the potential limitations for retasking under most circumstances, how then can the air commander be aided in taking advantage of opportunities during the battle and shaping his forces to take and maintain the initiative? A first cut at the problem seems to suggest that aiding can deliver the biggest payoff by reducing the ATO cycle from its current length of 24 to 36 hours down to a range of 3 to 6 hours. Reducing the cycle time from allotment to aircraft-in-the-air to around three hours would still require the same infrastructure as mentioned above but would give the air commander a campaign force responsive to his requirements. This capability has far-reaching effects. Munitions loading and between-flight aircraft servicing/maintenance, "turning" an aircraft, are currently timely functions that would have to be made faster to realize the advantages of the reduced ATO cycle. The potential impact of the reduced ATO cycle also needs to be studied in areas such as base facilities support, the number of crews required, crew fatigue, regular aircraft maintenance, the number of aircraft available, and the number of sorties that could be theoretically used in a reduced cycle versus the number which can actually be supported.

Conclusions and Recommendations

The points made in this third and last section are presented in detail in Appendix C of this thesis. Appendix C is a presentation of the observations, conclusions, and recommendations which were made over the course of this study and which were noted at the time in the author's "hook book." A hook book is a compilation of thoughts, observations, conclusions, and so on gathered over time so as to determine basic trends, requirements, and findings. It is the point paper of scientific journals. Therefore, it is suggested that the reader refer to Appendix C for a more detailed discussion of the following points.

(Note that the author is defining some comments as an observation versus a conclusion due to the lack of data from a field test involving the participation of actual users. Those items tagged as conclusions are so labeled because of the personal experience of the author, as surrogate user, while developing the ECCO DSS functional display using the HyperCard application/environment and work with the user applying the techniques of storyboarding.)

As mentioned earlier, this section is divided into three sections:

1) Organizational Impact,

2) The ECCO DSS,

3) The Storyboard Process and Requirements Generation.

The first of the three sections, Organizational Impact, differs from the user's comments above by encompassing a larger organizational perspective.

Organizational Impact: Observations and Recommendations. The first major observation is actually a point recommended as requiring extensive research in the form of operational field testing. As a result of a detailed examination of the tactical air control system (TACS) in its proposed enhanced and modernized future form, it does not appear that the dynamic retasking of air assets will play as significant a role in increasing the effectiveness of the air commander as had been initially hypothesized at the beginning of this study. As discussed above, this is primarily due to the limited time available to complete the full decision-command cycle and the ability of the humans to work within the typical limited time spans which would be seen for retasking. Instead, the author believes that reducing the decision-command cycle which results in the ATO would provide the air commander with flexibility that would show a greater overall and incremental payoff due to the ability it would give to the commander to coordinate all of the diverse air asset capabilities against the evolving threat in a responsive manner. This would allow the commander to both react to an enemy thrust as well as gain the initiative for himself, resulting in an air commander gaining the momentum and enabling him to dictate the circumstances of the battle.

Secondly, for the implementation of EC retasking there is the question of where to place the ECCO in those theaters where there is more than one TACC-like control organization. Due to the scarcity of EC assets it is only possible to have the flexibility to retask assets if the airborne assets of the entire theater are considered. Where retasking requires the tactical redistribution of assets across command boundaries, the question of authority to give the appropriate orders elevates the issue to the next level of command. This generally means that a command level which normally is tasked with the operational/campaign level of the war has to become involved in real-time tactical decisions. Thus the question arises whether the ECCO should be assigned at the theater level of command to advise the theater-wide commander or at the tactical level and elevate questions of cross command retasking as needed, with the inherent time delay. This area requires further research.

Third, as discussed under User Reaction, to accomplish either retasking or reduction of the over-all theater decision-command cycle, the TACS requires extensive modernization of its equipment and enhancement of capabilities such as real-time intelligence input and secure, jam-resistant communications and coordination.

Fourth, the Air Force must establish a system for the coordinated management of decision aids. Personal experience has shown that research is being done on projects that duplicate each other, as well as the work of this thesis, without the separate managing offices or this author being aware of each other's initiatives. Parallel research efforts and redundancy have strengths and advantages that often justify their use. These strengths and advantages did not seem to be needed or used in the case I am citing. There was obviously inefficient use of limited resources, both money and talents, without any apparent cause. This can not be afforded at any time and especially at a point in time which appears to be ushering in an era of declining funding for the foreseeable future. The central coordination of these efforts will at least allow the sharing of information from hard won lessons and save others from "reinventing the wheel."

Fifth, after the completion of this thesis, a comparison of this research with that of a commercial contractor's work showed striking parallels between the two projects. The obvious question is what was the difference in cost to the Air Force of having a single user develop the requirements for a future system using storyboarding as opposed to a contractor team developing the same list of requirements using any method? And if it is possible to have using organizations developing their own system requirements, with the obvious incentive that implies, while not degrading their assigned missions, why should the government pay to have outside contractors do this work?

Lastly, for organizational impact, the implementation of the adaptive design will require that the Air Force adopt a flexible, decentralized philosophy toward the support of systems developed under this concept if the Air Force is to realize the advantages of systems responsive to the local user. This could be done by supporting the various levels of the system at the lowest organizational level possible, from it central, standardized core supported at the Air Force level to its specific user oriented "surface" features supported at the wing level.

ECCO DSS: Conclusions and Recommendations.

Conclusions. As no operational system was developed and tested by a using organization there can be no conclusive finding as to the validity, worth, or operability of the Electronic Combat Coordination Officer's Decision Support System or the organizational/systems concepts put forward in the body and appendix of this thesis. To arrive at a conclusion concerning a ECCO DSS will require further research, development, and operational field testing within a GREEN FLAG setting, at least, by AFIT/ENG in conjunction with such organizations as HQ TAC/DR and HQ ESD/TCR.

Recommendations. As mentioned above, a great deal of further research is required for the development of an operationally usable and user accepted ECCO DSS.

1) ECCO DSS Development. It is recommended that AFIT/EN work in conjunction within the currently established command

aiding structure headed by HQ TAC/DR and HQ ESD/TR in further study of the concept of EC retasking and reduction of the ATO cycle. Field testing of both the system and especially the operational doctrine are critical to the successful study of this capability. Additional agencies that should also be included in the effort are the Tactical Air Warfare Center (TAWC), the Air Ground Operations School (AGOS), the 65th Air Division, ATOC Sembach, the 507th Tactical Air Control Center, the Air Force and Joint Electronic Warfare Centers, and the Rome Air Development Center.

Several additional capabilities must also be developed for the ECCO DSS which have been suggested via the storyboards and the HyperCard-based functional display but were not conceptually pursued due to time restrictions. These include:

2) Deconfliction (Frequency and Airspace). The ECCO must also have the ability to assess the potential for conflict and its impact on currently scheduled uses of both the electromagnetic spectrum and airspace. Once the impact is assessed, the ECCO must have the ability to generate plans which will minimize the impact. This capability would already exist in the general planning capability of the DSS. If conflict can not be avoided and it is determined that the impact does not degrade the other unit's capabilities too seriously, the ECCO must then have the ability to communicate a warning notice to the affected units.

3) Models. There must be developed and added to the DSS those models which will allow the "what if" planning capability which is a fundamental characteristic and strength of a DSS. The results of the specific models are identified via the storyboards of the proposed DSS. Examples of needed models include:

a) EC aircraft models with EC and flight characteristics modeled,

b) EC effects models which model the impact of EC effects on targeted systems,

c) SAM radar and missle models which take into consideration such factors as terrain, weather, and system reliability to allow the simulation of alternate missions.

Also important is the fact that to be truly usable for joint operations such as in NATO the DSS must also include the capability to plan for the employment of all EC assets within the alliance (to include US Navy EC assets which are of course always "in support of").

4) Mission Impact. To support the ECCO's ability to evaluate operations the ECCO must have a basis of value comparison. One suggestion is to use the Loss/Damage ratio as a basis of comparison between missions with varying EC packages. Use of the Loss/Damage ratios entail comparing the difference between two mission's ratio of their expected (simulated) losses versus their expected (simulated) destructive impact. The ECCO must be able to determine a loss/damage ratio for both the overall force and the EC assets when proposing a change. This is required to allow the ECCO to select among alternative plans. This will also enable the ECCO to determine, among other things, the incremental benefits to a mission receiving retasked EC assets and the impact on future missions of losing an EC asset.

5) Asset Valuation. Inherent in the last function mentioned above is the capability to determine the worth of EC assets to the overall capability of the air commander. The difference in theLoss/Damage ratios will establish the value of the EC asset. This is a valuation ability that does not exist to the knowledge of this author but which does need to be developed.

Further improvements include:

6) The addition of functions to support degraded operations such as enabling the assignment of dynamic confidence ratings to information and the capturing of recent battlefield trends to project current and future operations when input support systems have gone down.

7) Adding powerful memory aids to provide planning information on each of the various assets as well as the mixed operations of different aircraft. Another area requiring memory aid support is the commander's guidance for overall objectives and other similar critical information.

8) The possible addition of an expert system to guide and short-cut the planning process thereby speeding up the generations of plans

<u>The Storyboard Process and Requirements Generation.</u> This research set out to develop an initial set of requirements for a decision support system to aid the dynamic retasking of EC assets. It was decided to investigate the use of the storyboarding process as a vehicle through which these requirements would be determined. Additionally, it was further decided to investigate the use of the HyperCard application as an environment to create a "functional display" of the proposed system using the developed storyboards. Due to time and user equipment limitations there was only one review of the storyboards by the user, though it was quite favorable as mentioned above, and no comment on the HyperCard-based presentation as the user was unable to review it. As a consequence of these limitations a finding by the author that could not be field tested using the volunteer organization has been included here merely as an observation because it is significant and warrants further study.

Conclusions.

1) The use of concept mapping allows the accurate bounding of the general subject being aided as well as a selected kernel process. It also eases the identification of key functions requiring the support of specific DSS operations.

2) It is very difficult to stay within the identified bounds of a kernel due to the extensive overlapping of processes within a complex system. It is relatively easy to avoid this through constant referral to the concept map to assure the appropriateness of the next development step.

3) The user generation of requirements through the process of storyboarding will work but only if the following conditions are met:

A. The designer works with the user to develop a ready library of icons, frames, and whatever else is required to prevent the user from having to generate the storyboard building blocks from scratch. This a tedious process which may well result in the user losing interest in the process if he is required to generate it all from the beginning. Additionally, prepared building blocks act as an anchor or starting point from which the user can evolve.

B. The user(s) must be allowed time to work on the storyboards or functional display on a regular (daily) basis to insure basic trends and requirements are captured . The issue of gaining and maintaining the interest and cooperation of individuals who are not interested in the effort and thus do not put forth a serious effort needs to be addressed. The issue of breaking a user free from the pressures of daily commitments to work on the generation of requirements also must be addressed.

4) Through the use of the storyboarding the user's information inputs are forced to become concrete and unambiguous. The development of the storyboards requires the user to develop a detailed description of at least the operational system's required

representations, operational functions, control mechanisms, and possibly the system's memory aids. The presence of a common, concrete storyboard representation also helps to minimize user-designer miscommunications about desired system requirements (It is expected that the use of the functional display, using the HyperCard/ hypertext environment, will further enhance user-designer communications and reduce chances for lasting miscommunications).

5) The concept of a functional storyboard display is very useful in establishing system requirements, and the user generation of the requirments, because it provides a structured framework which forces a thorough analysis of the system's required features and operational interconnections/functional relations. Additionally, the ease of use of the HyperCard application/environment makes constructing the functional display easy, thereby further opening the possibility of the direct user generation of requirements as opposed to their generation through the use of a designer or design team. The user generation of requirements is also supported or made possible by the reasons cited below:

A. First, the creation of the functional display reduces any initial conflicting functional demands and ensures that over time there is no forgetting or confusing how functions are interrelated and points out to the user those linkages which are contradictory.

B. The analysis of a proposed system is made easier with the construction of a functional display because it is a shorter step between the functional display and the operational system and therefore easier to conceptualize and define the final operational system.

C. The generation of a functional display needs to be supported by an environment which combines HyperCard linking and support capabilities, easy access to an icon library, and a construction capability such as is offered in the MacDraw application. If this is not possible, then it is important to tie the separate applications together with an application such as Switcher which allows the easy, quick transition between the functional display environment, the construction tool, and the icon library. This is to provide the user with the tools which will cause the least interruption in the thought process while working on the function display and therefore a better chance of early development of stable requirements.

As a general statement, it can be concluded that the use of concept mapping and storyboarding allowed the determination of a set of functional requirements for an command and control decision aid. There is no reason to expect that this approach for requirements generation can not be used in other fields with equal success. It must also be said, on the other hand, that no actual system was developed, fielded, and tested for both user acceptance and major user-required modifications to establish validity and stability of the generated requirements. A requirement is stable if it represents a basic requirement of the system to meet general on-going operations or the result of a transient or scenario-specific need. Additionally, as both the function of retasking and the adaptive design of operational systems has still to be organizationally adopted, the requirements derived to date are based only on those needs as perceived by a surrogate user. This must be pursued in further research.

Recommendations. Within the general subject area of the storyboarding process and requirements generation there are far fewer recommendations than were offered for the specific subject of the ECCO DSS.

First, there is a great deal of work needed on the theory and practical application of alternative generation. In Appendix C the idea of setting up a library of templates is offered as a possible solution but it is hoped that the kind of solution which templating represents, brute force, will not be the only solution possible. It is hoped that original generation of alternatives can be achieved.

Second, research is needed into the possibility of converting the desired portions of a kernel concept map into a check list, or some other guide, to help the designer/builder stay within the bounds of the kernel and not waste resources working in peripheral areas.

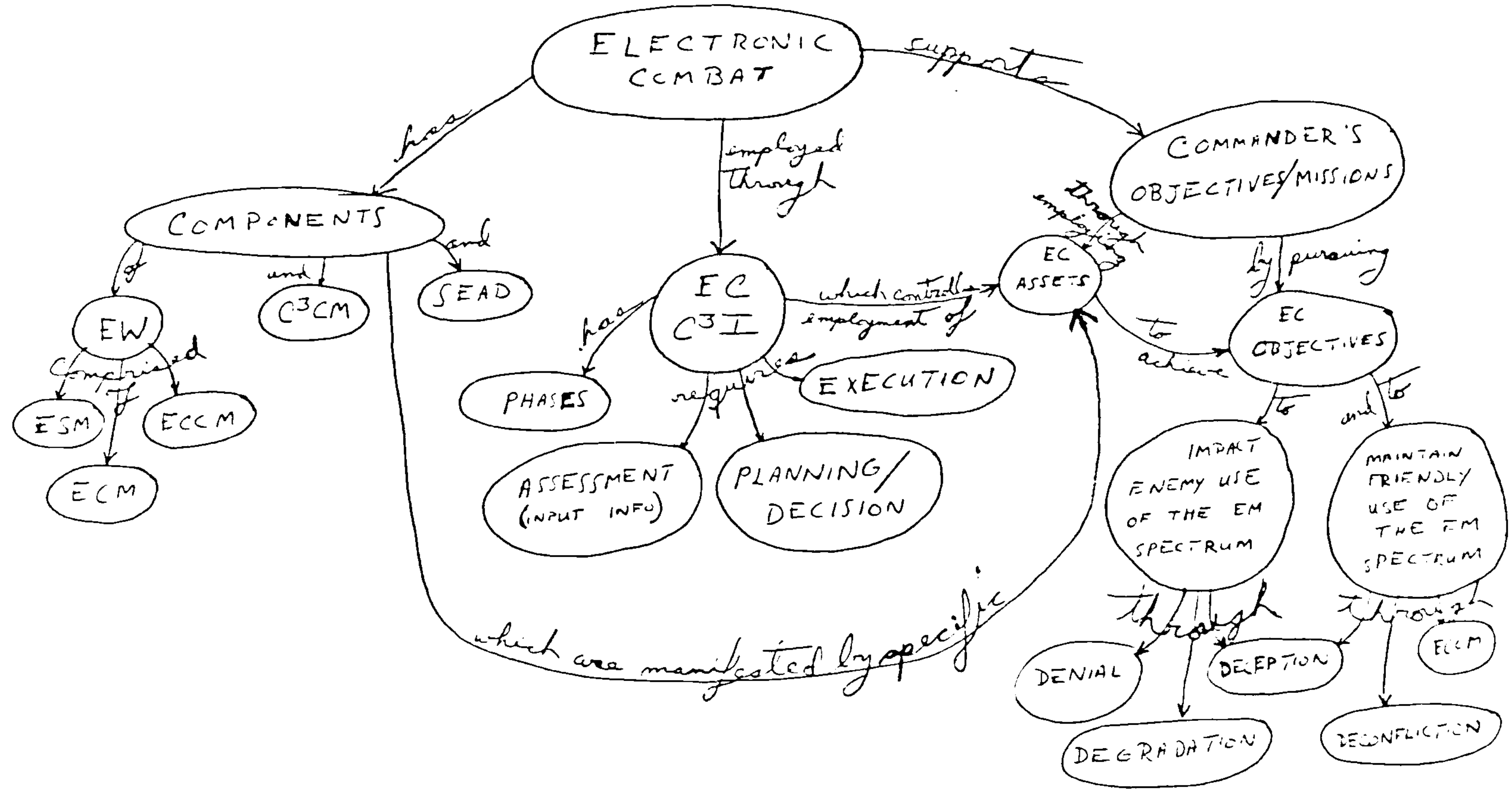
Finally, research needs to be conducted with operational organizations on the user construction of storyboards and functional displays. The aim of these studies would be to determine the viability of the user generation of systems requirements. Additionally, these studies would also need to test all aspects of adaptive design systems development process, from requirements generation to adaptive design modifications to the evolution of a relatively stable system (The user generation of requirements will enable the concentration of limited government funds on the employment of contractors for the productive purpose of building systems that are already defined as opposed to the initial generation of requirements).

Appendix A: Consolidated Concept Maps for the Command and Control of Electronic Combat with Emphasis on the Real-Time Retasking of Airborne EC Assets

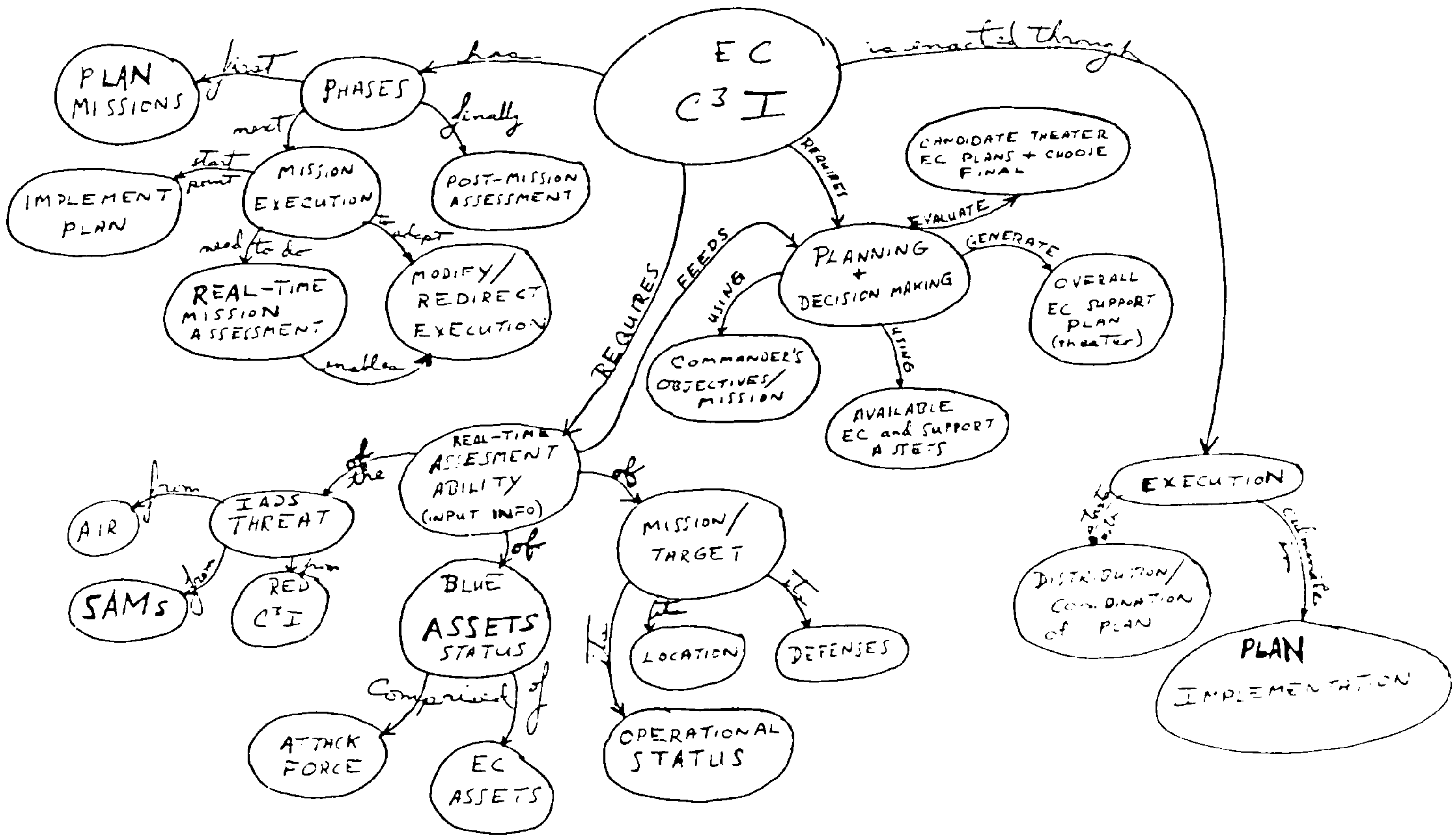
This appendix contains the composite concept maps used for the development of the ECCO DSS storyboards. These concept maps are the result of consolidating the views of many different people associated with tactical air command and control operations. Among the people interviewed for the construction of these maps were personnel of the 507th Tactical Air Control Center, HQ USAF/XOORC (Tactical Command and Control Division), and the USAF Tactical Air Warfare Center (TAWC).

Pages 59 through 65 constitute the first set of concept maps. Pages 66 and 67 reflect changes to the initial set of concept maps. These changes are the result of subsequent reviews of the initial set of concept maps by the 507 TACC, personnel of the TAWC, and continued assimilation of information by the author.

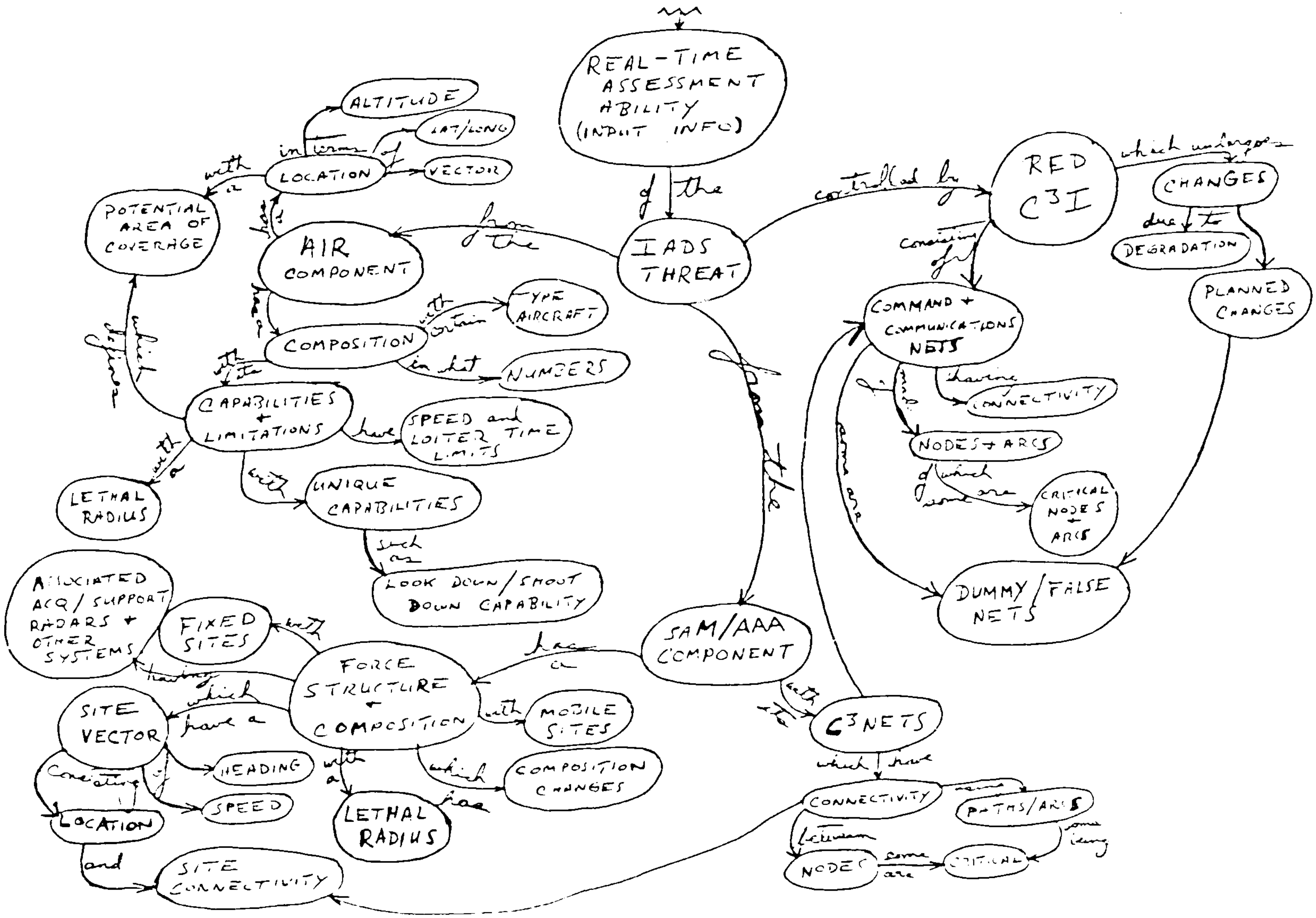
The change on page 67 is a recommendation designed to address an apparent deficiency in the education and practice of both planners and commanders alike. According to members of the faculty at the USAF Air Ground Operations School, personnel of the 507 TACC, and observations of this author, while the Principles of War are terms which are taught in Professional Military Education courses, these principles do not exist in the minds of planners as the essential, living, and overarching framework to guide the development and execution of plans. The worth of these principles are proven throughout the pages of history and still have the same applicability today. The principles, as a framework, exist to serve as a guide and insure that both commanders and planners are aware of all aspects of warfare and fully plan for war's many facets. The living existence of these principles can only be fully achieved and used if they are an integral part of the education, training, and the memory aids of support systems which the user can query. The ability to prompt such a memory aid will help ensure that all aspects of the war planning and fighting have been considered in light of the fundamental principles of war.



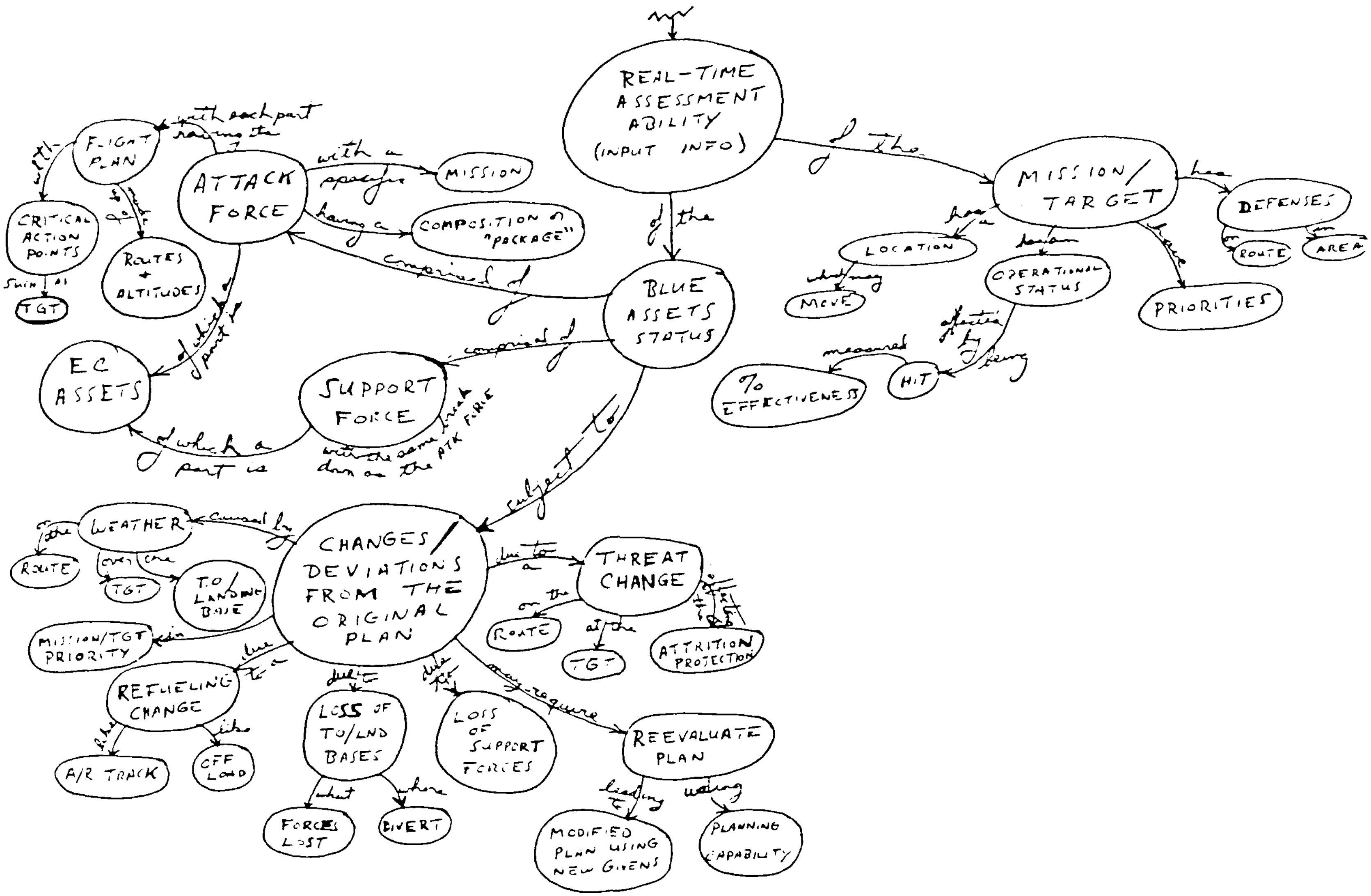
Concept Map of Electronic Combat (EC): Overview



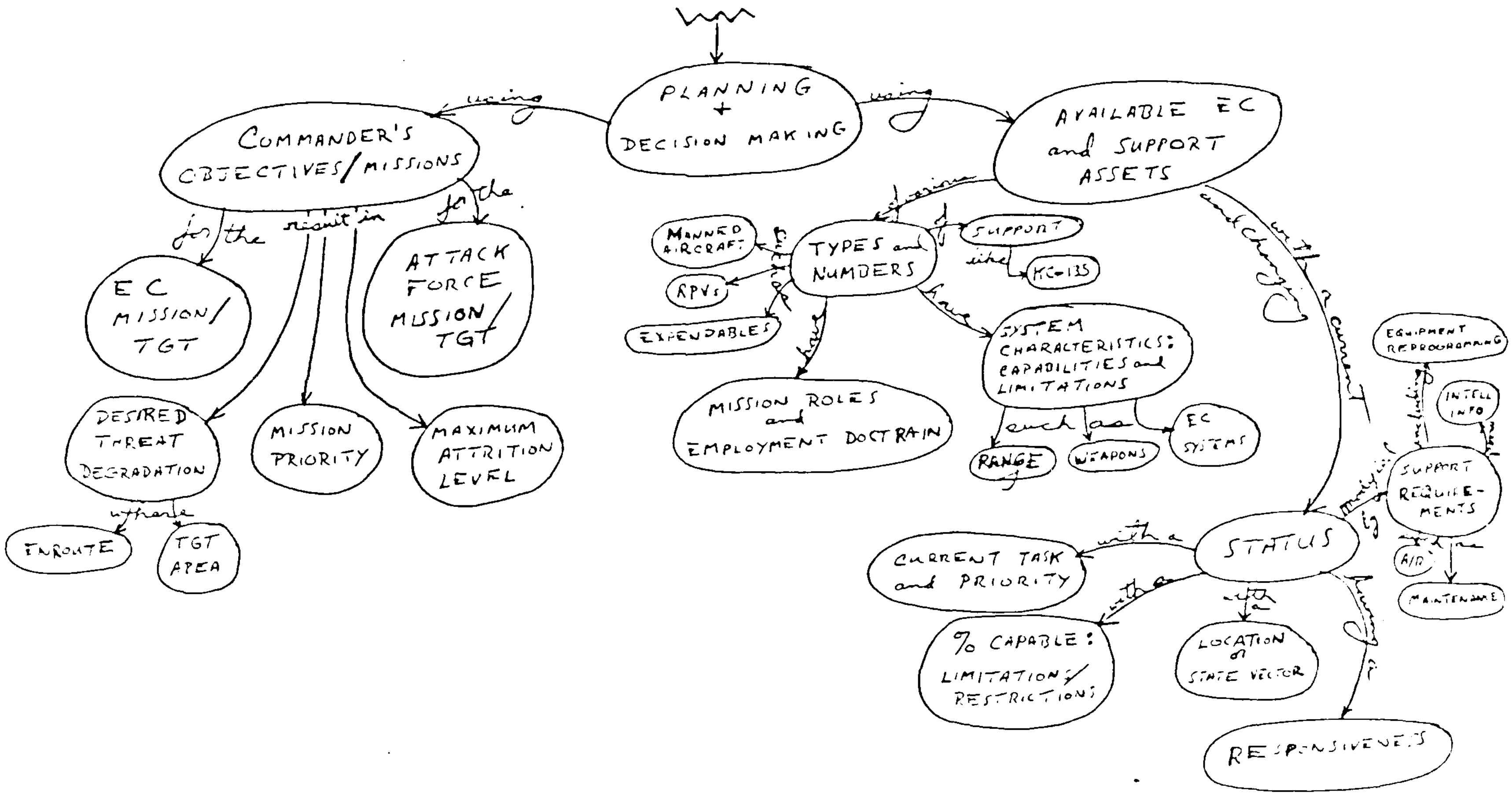
Concept Map of Electronic Combat: Command and Control



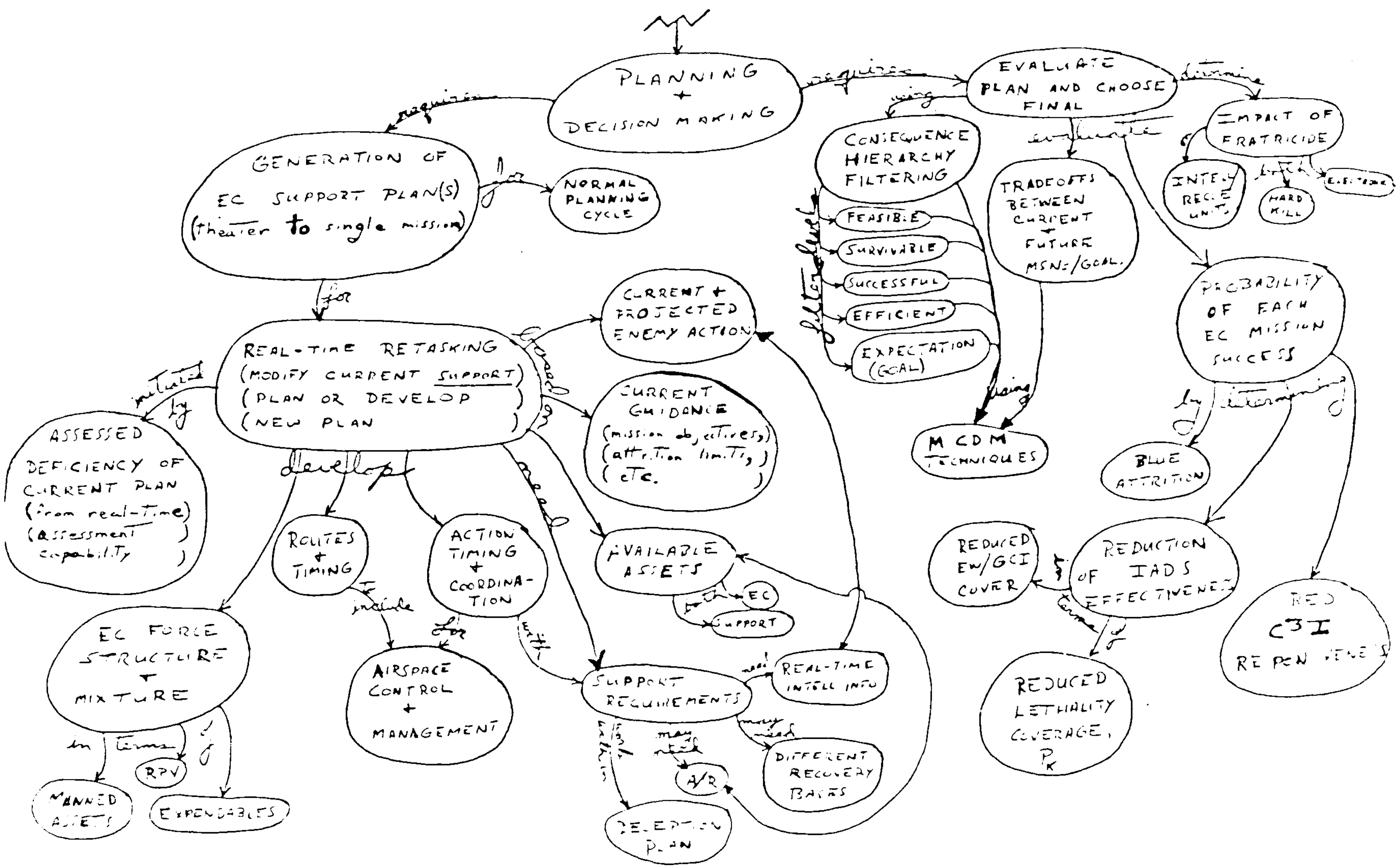
Concept Map - EC: Command and Control: Assessment, IADS



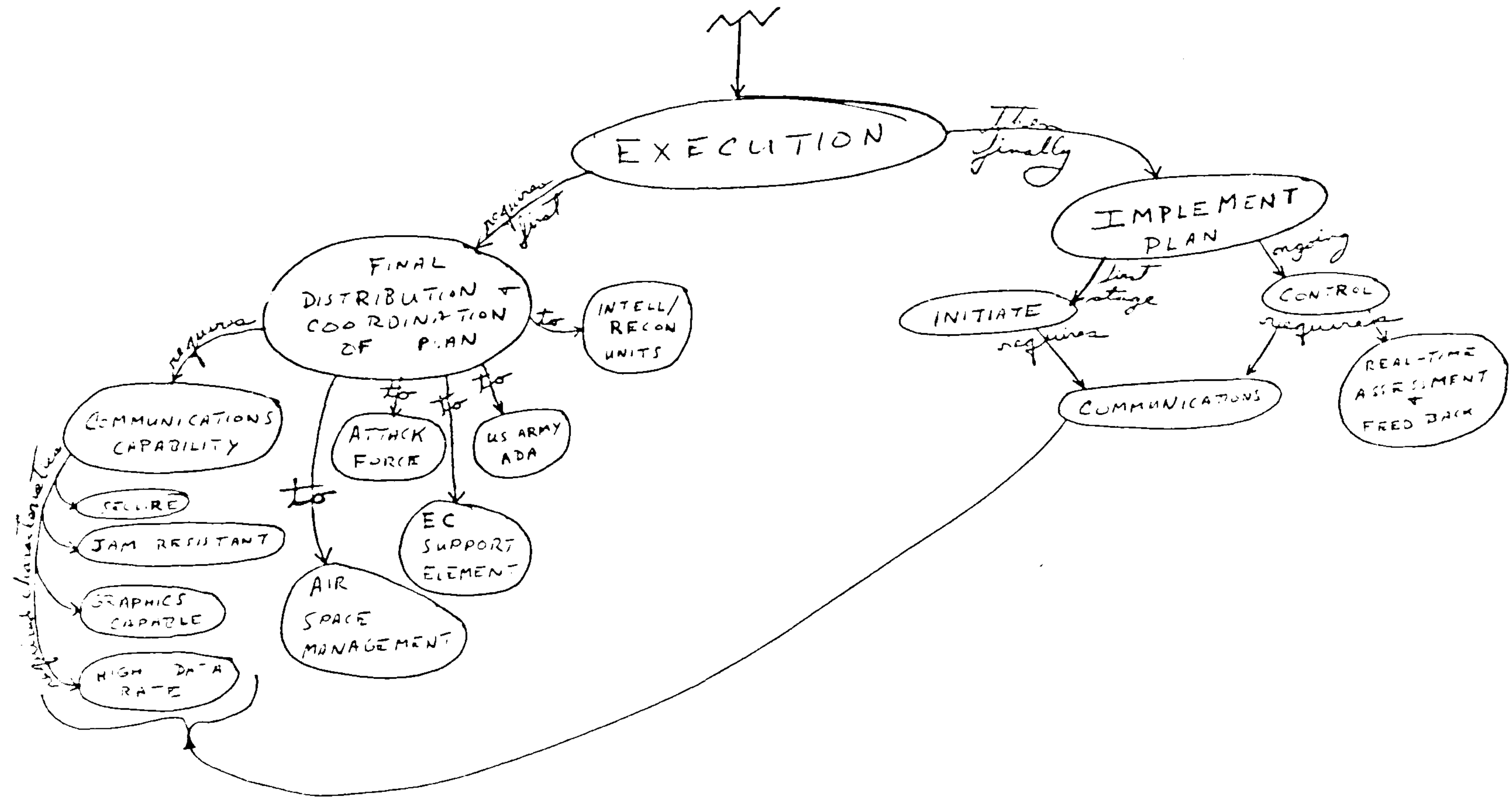
Concept Map - EC: Command and Control: Assessment;
Blue Assets Status, Mission / Target



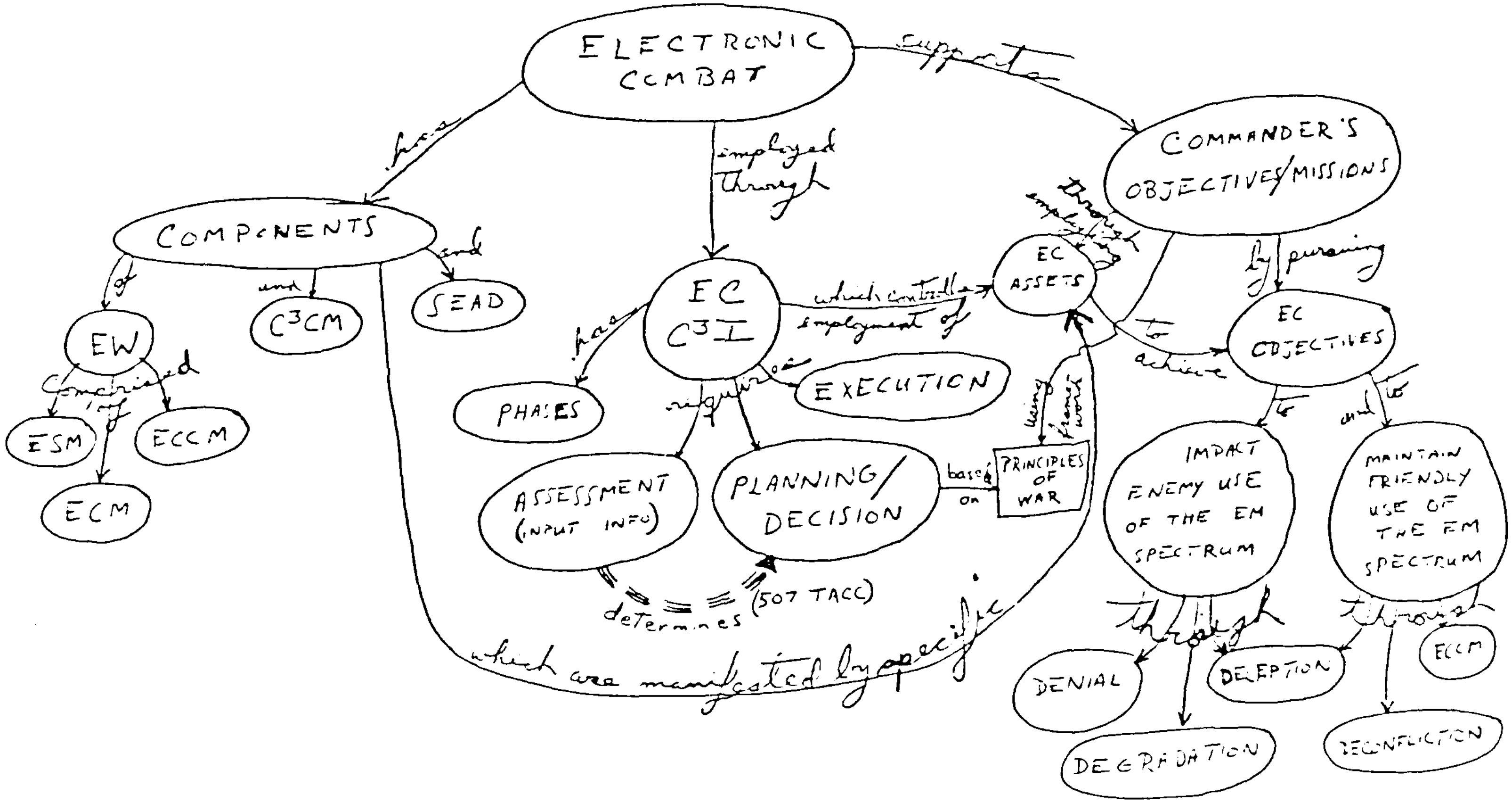
Concept Map - EC: Planning and Decision Making; Commander's Objective / Missions, Available EC and Support Assets



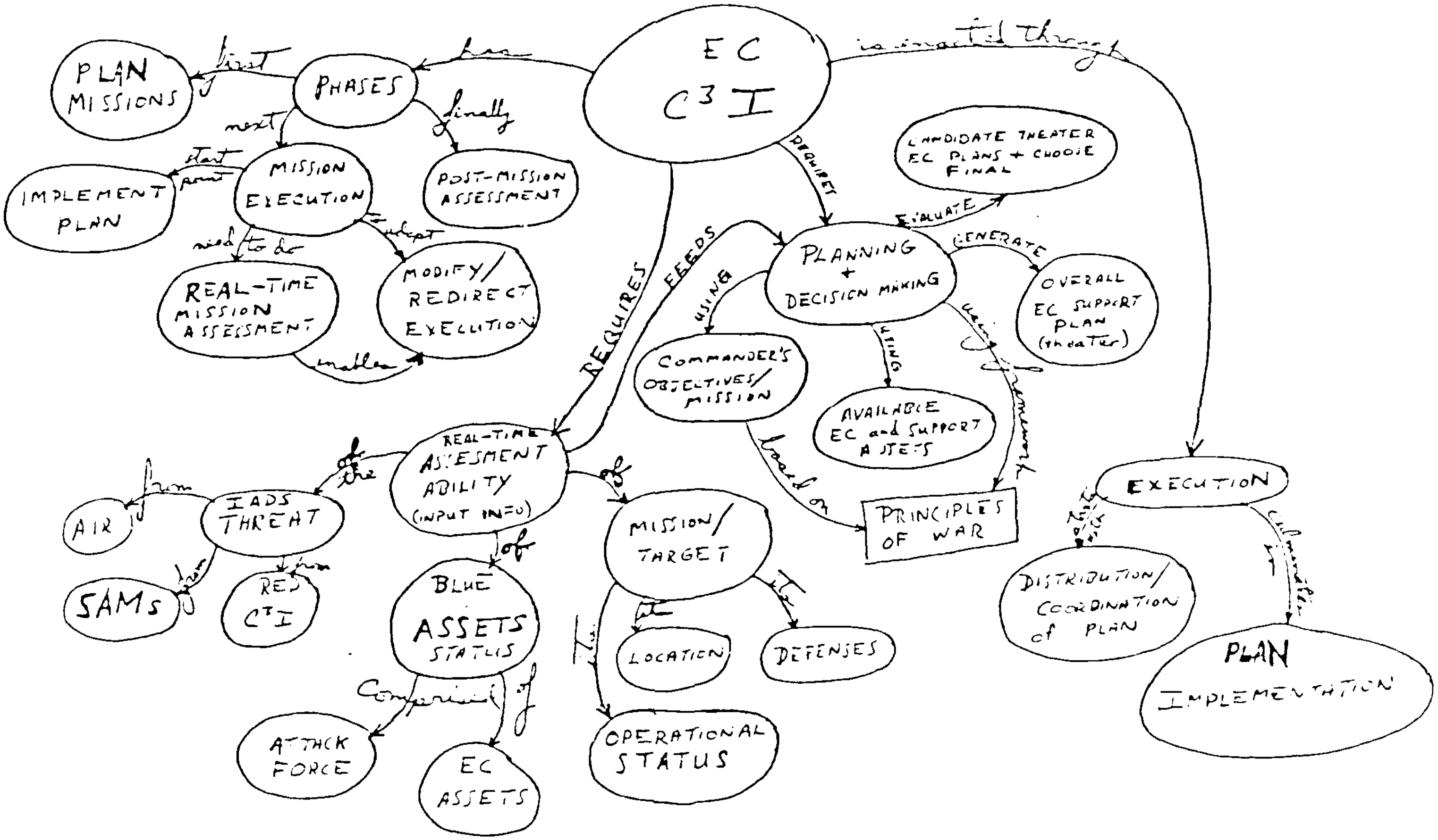
Concept Map - EC: Planning and Decision Making; Generation of EC Support Plan(s), Evaluate Plan and Choose Final



Concept Map - EC: Execution; Final Distribution and Coordination of Plans, Implement Plan



Concept Map of Electronic Combat (EC): Overview;
Changes: (1) Author - Added Principles of War
(2) 507 TACC - All other additions



Concept Map of EC: Planning and Decision Making; Commander's Objective / Missions, Available EC / Support Assets
Changes: Author - Added Principles of War

Appendix B: Storyboards for the Electronic Combat Coordination Officer's (ECCO) Decision Support System (DSS)

The ten storyboard sections which follow were prepared to explore the idea of generating system requirements using the storyboarding process in support of the adaptive design of a decision aid. Each section starts with a general explanation of the storyboards in that section. Specific information on the menus and buttons will be found in the Help storyboards.

The storyboards were specifically prepared to depict the proposed capabilities of a decision aid to support the ECCO in the single task of assessing the impact of the enemy's IADS on current missions. Some initial steps were also taken toward depicting capabilities to support the generation and evaluation of alternate plans to point out the need for a simulation capability. Only a single aspect of the ECCO's overall functions is intended to be fully supported in these depictions because this decision aid is being developed under the adaptive design approach. As such, only a single area of responsibility was selected for initial implementation. Additional functions would be added as each previous area became relatively stable.

The storyboards presented are of only two basic formats, the Operations Area Overview display and the Help text display. The Help text is presented in the same menu/button frame as the Overview presentations but the buttons and menus are non-functioning except the added RTN (return) button. The fully developed ECCO DSS would have a variety of formats/presentations in conjunction with the capabilities required to support a wide variety of tasks. The presentations for a fully operational system would therefore range from lists to spreadsheets to cartographic presentations.

At the bottom of each storyboard is an exploded menu display, or feature chart, which is highlighted to show the user his exact location within the DSS.

The proposed Operations Area Overview representation of the ECCO DSS is designed to give the user a quick but accurate and complete idea of the context of the operation(s) which may be of interest. This presentation will allow the user to arrive at conclusions and decisions based on a comprehensive and detailed understanding of the environment by allowing the ECCO to select for presentation any level of information concerning the present threat environment, from a single site to the entire IADS and additional information. This is true whether monitoring actual missions or developing a new plan using the aid's simulation capability. Examples of some of the specific types of presentations which can be displayed are flight paths, orbits, the location of a theat, the type of threat, threat ranges, the effect that altitude variation has on the threat characteristics, individual or aggregated forces, as well as a number of other things. An example of the ability this representation gives the ECCO is using the altitude variation control on the SUPRT/AIR CNTL - ALL display to search for threat-free ingress routes through the enemy IADS which developed because of terrain masking.

The operations available to the user of the ECCO DSS support all phases of the decision cycle. The presentation of information on both enemy and friendly forces enables the ECCO to anticipate potential problem areas. This capability is backed up by automatic features which alert the user in the case that there are deviations from the plan which exceed default or user-specified error margins. The presence of aircraft and threat models allow the construction, simulation, and rough visual evaluation of alternative plans. Future expansions of the DSS under the adaptive design process will allow the more detailed analysis of the alternative plans by using such criteria as loss/destruction ratio. A further expansion of the system will allow the automatic generation of flight/mission information for the retasked and supported aircraft to support the command and execution of the selected retasking plan.

The ECCO DSS has a myriad of memory aids for use both with the initial operating capacity and later expansions. These include such aids as friendly organizational ground force boundaries, friendly ADA positioning and status, state vectors with varying information for both surface and airborne forces, extensive data bases to support models or be scanned by the user, system default values for the various presentations or for the configuration of the simulation models, a HOOK BOOK workspace for recording thoughts or other information which automatically copies the display the user was on when the Hook Book was requested so as to preserve the context of the user's thought, and many other aids.

The number of control mechanism available is extensive. A thorough reading of the HELP file will show the user the many different ways in which to use the representations, operations, and memory aids in the process of arriving at a final decision or in generating and evaluating flight missions.

Table of Contents: Appendix B Storyboards

Introduction

The INTRODUCTION storyboard welcomes the user to the functional display of the ECCO DSS storyboards and briefly explains the purpose of the presentation.

The HyperCard page is a scrolling text field which the user can read. There are no operations or memory aids associated with this storyboard. The control mechanisms on this storyboard are the HOUSE and BEGIN buttons which respectively allow the user to move to the HyperCard HOME card or start the ECCO DSS presentation.

(DO NOT WORK IN THIS UPPER AREA AS IT IS HIDDEN ON A SMALL MAC.)

WELCOME TO THE ELECTRONIC COMBAT COORDINATION OFFICER'S (ECCO) DECISION SUPPORT SYSTEM (DSS) FOR THE DYNAMIC RETASKING OF ELECTRONIC COMBAT (EC) ASSETS

by MAJ CHARLES D. FLETCHER

BEGIN

INTRODUCTION

The accompanying HyperCard stack is an automated presentation of the storyboards for the proposed Electronic Combat Coordination Officer's (ECCO) Decision Support System (DSS). While it is a fuctional display, there is no software, such as a model or data base/DBMS, "behind" the presentations to make the system operational. Similarly, there are no active data or intelligence inputs to the system to make the battlefield presentations operable. This is strictly a functional display designed to give the proposed user an idea of what the system would look and feel like. As such, these storyboards act as a strawman for the user to use as a starting point, or anchor, from which to tell the designer what are the requirements for this type of system.

NOTES ON THE PRESENTATIONS

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NOTES ON THE PRESENTATIONS

The displays which are seen in this model are representative of what the full-up system would have. While the full-up system would have the ability to support the presentation of any combination of information requested, such as IADS - SAM, MOBILE and ATTACK GROUP - TARGETS (ALL), this presentation of the proposed system does not show that capability due to the thousands of possible combinations, the requirement that each presentation be custom made, and the time constraint of this program. Therefore, the displays shown here are generally confined to certain combinations under a single menu heading and generally exclude combinations of information which are the result of requests made under different menu headings.

xxx - Those menu headings or menu items that are nonfunctional are marked by an "xxx" before or after the item.

The start up, or default, screen will show the FEBA (Forward Edge

BEGIN

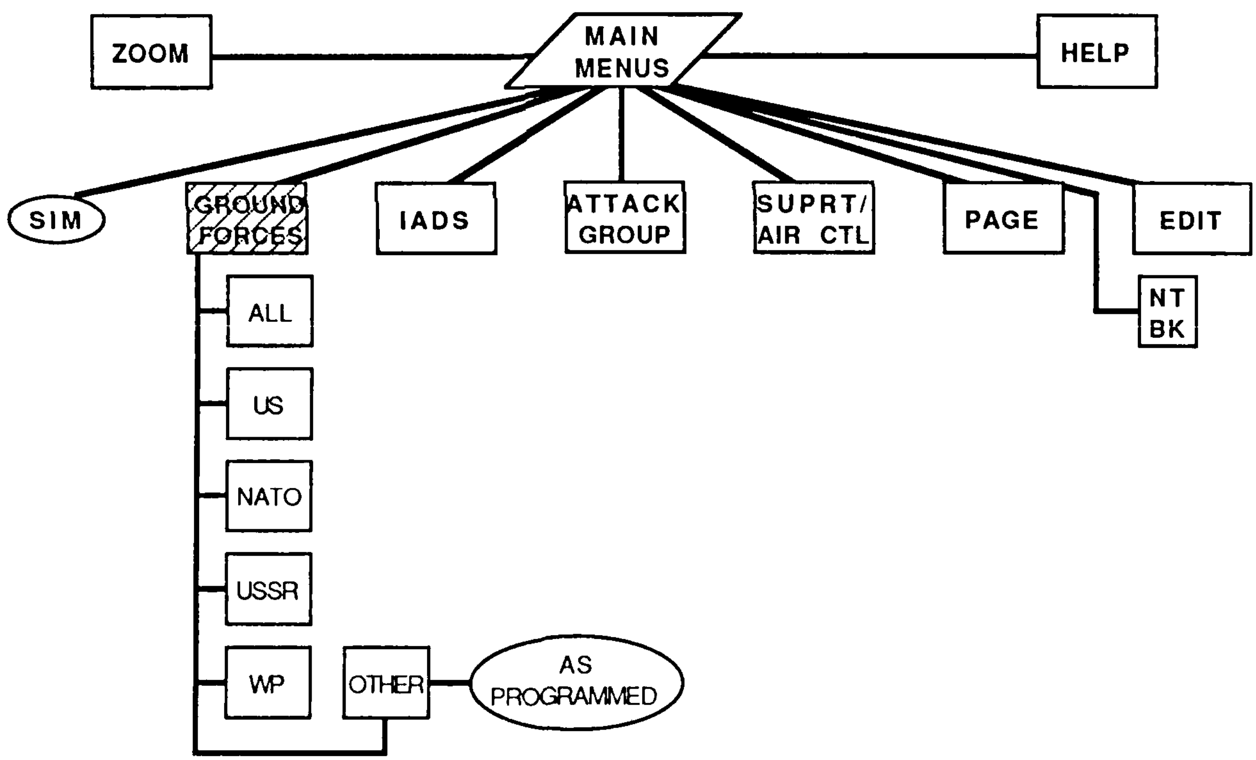
xxx - Those menu headings or menu items that are nonfunctio are marked by an "xxx" before or after the item.

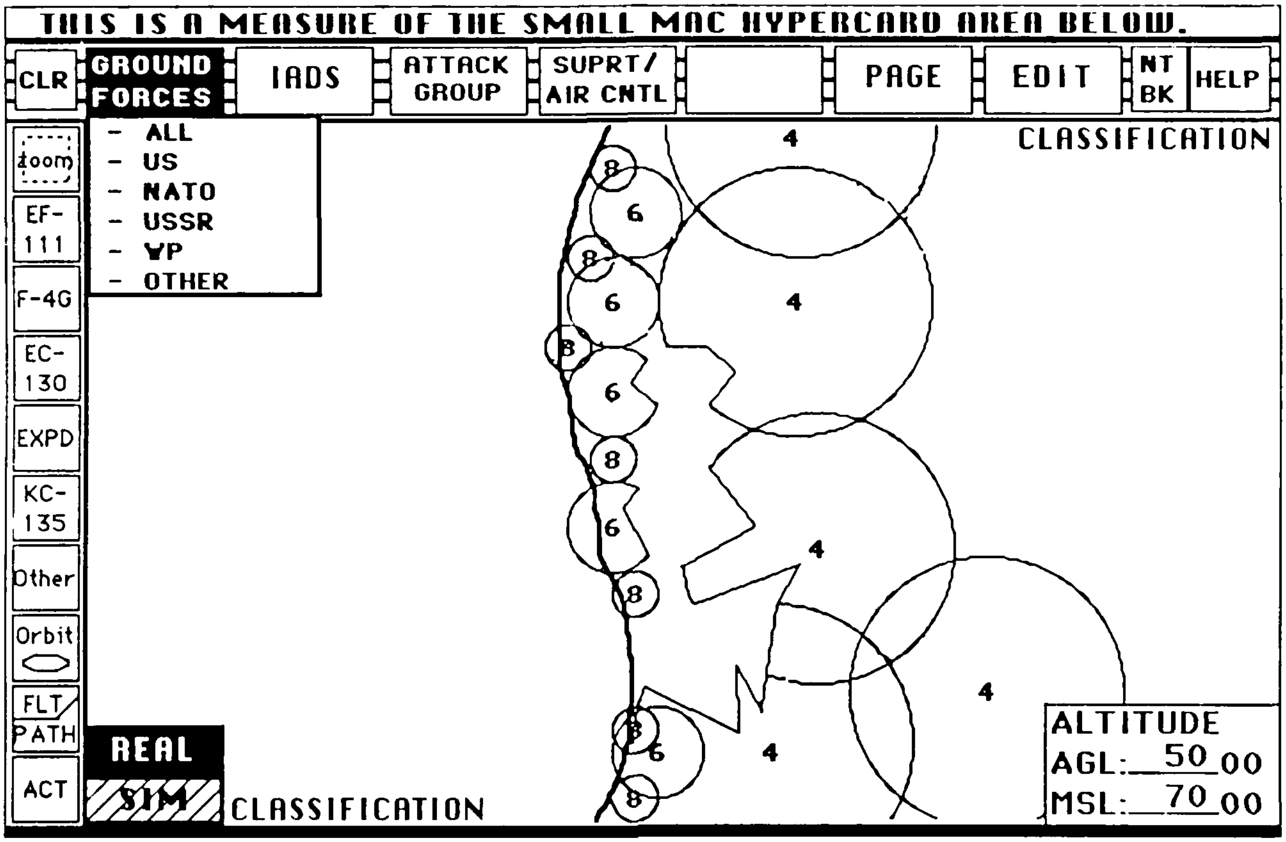
The start up, or default, screen will show the FEBA (Forward Edge of the Battle Area), the mobile SAM systems, and the rings of those SAM systems which define the maximum range of the associated missle.

Additionally, only one specific function of the proposed system is being presented for comment because this system is being developed under the adaptive design process. The function, or kernel, of the DSS being implemented here is that which assists the ECCO in assessing both the impact of changes in the enemy's IADS on the missions in flight and evaluating the desirability of retasking available assets to take advantage of those changes. While it is realized that other portions of the proposed system are eventually needed to fully support all aspects of the ECCO's duties, under the adaptive design process the additional functional areas are intended to be added in the future as continued points of growth for the system.

Ground Forces

The GROUND FORCES menu control enables the user to request the presentation of the selectable combinations of friendly and enemy ground forces. The organizational level of the units is either user selectable or a function of the size of the area being viewed. The latter is the default selection procedure. See the HELP file for a thorough explanation of the representations, operations, memory aids, and control mechanism available to the user on these pages.

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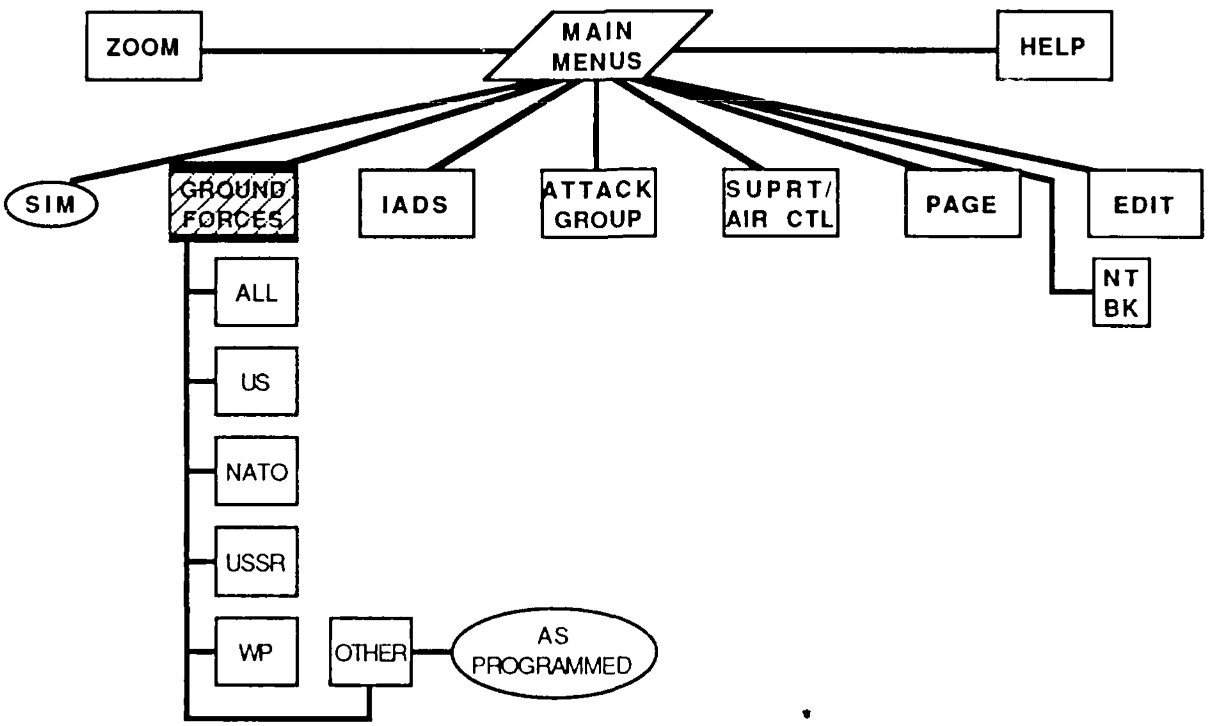
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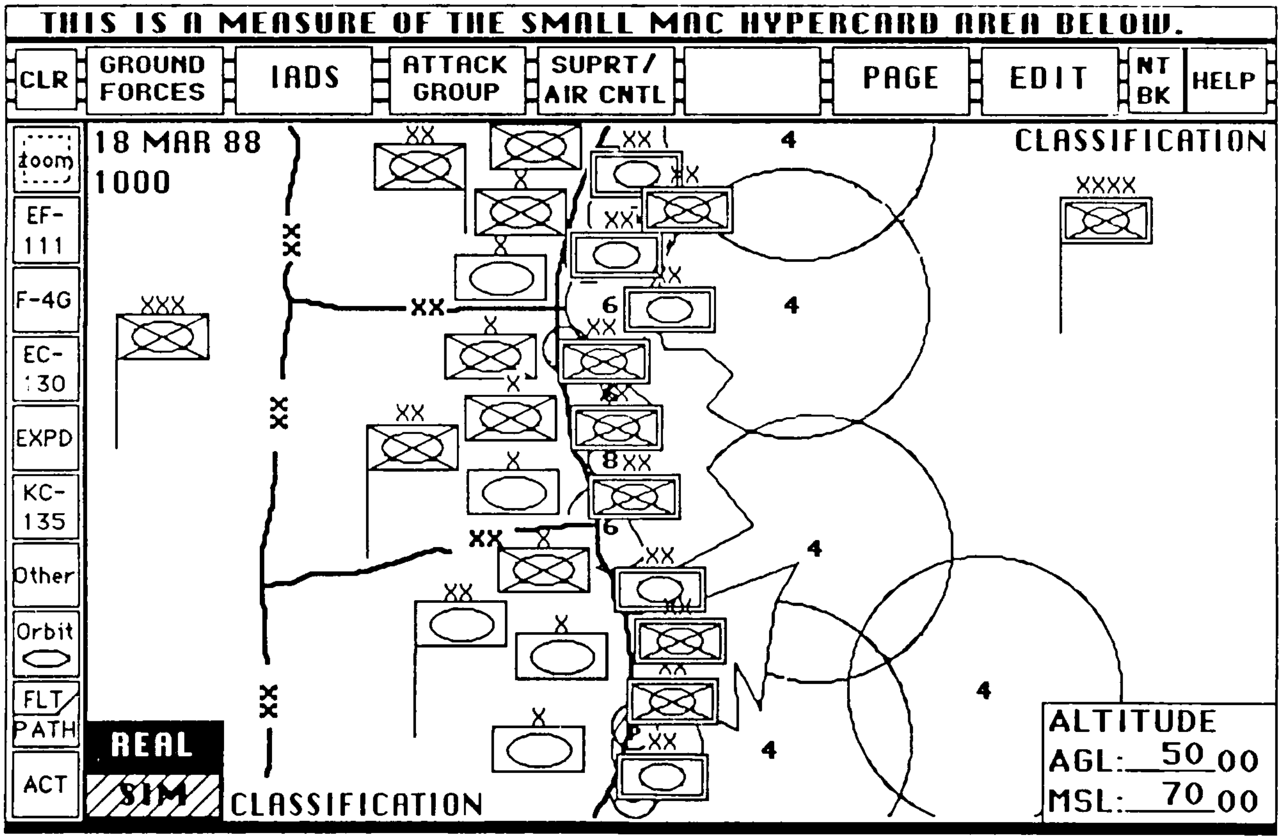
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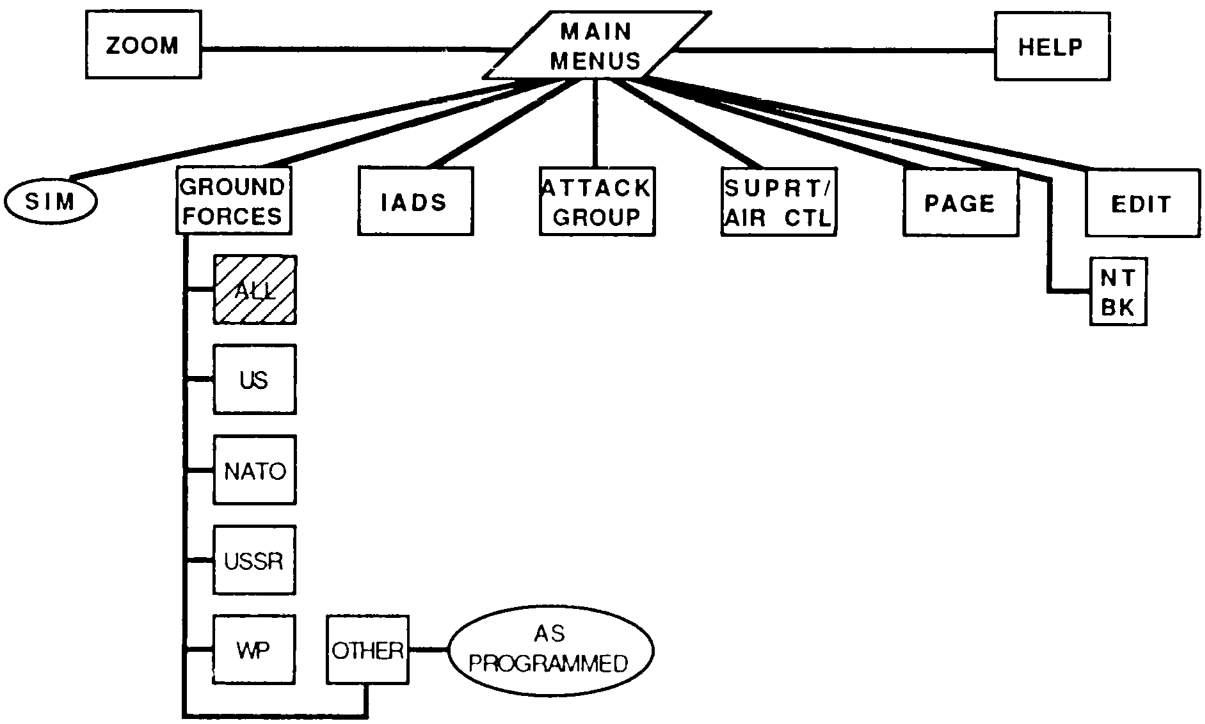
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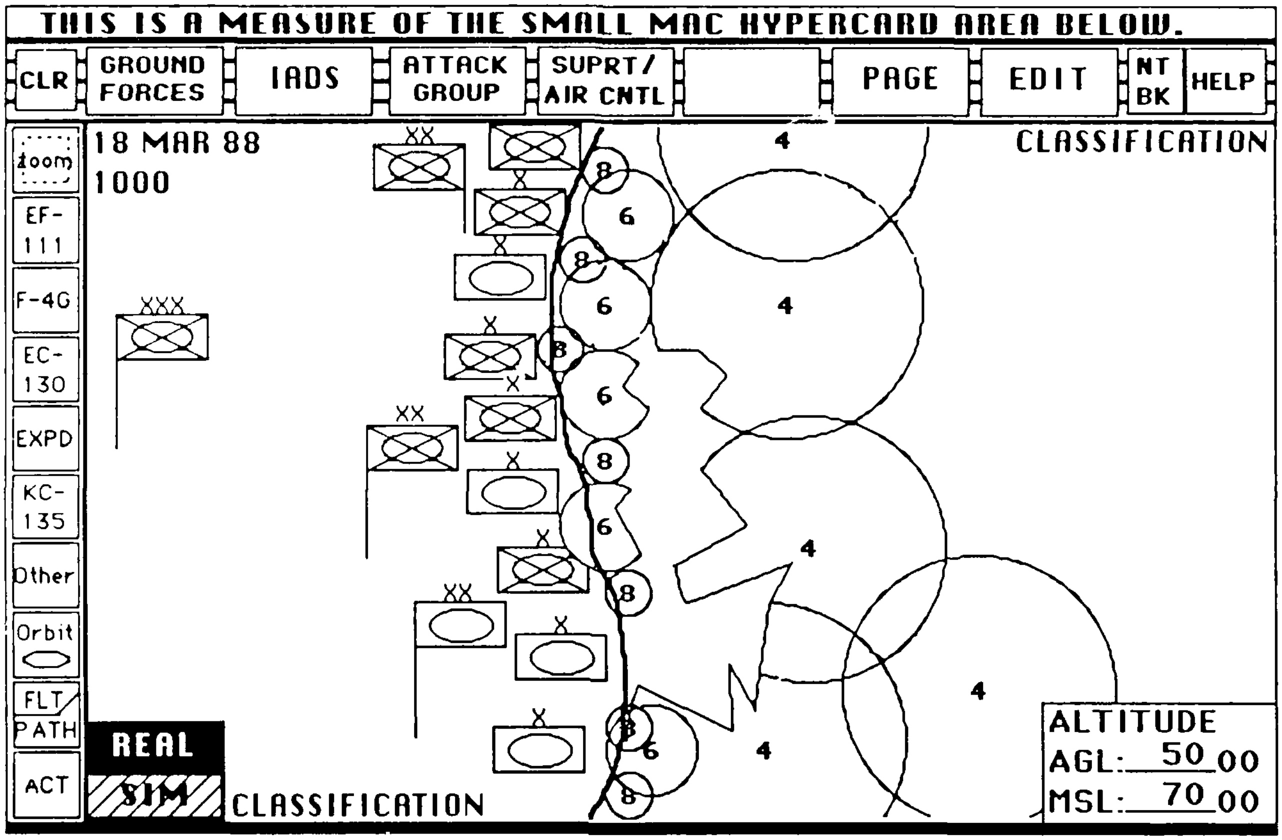
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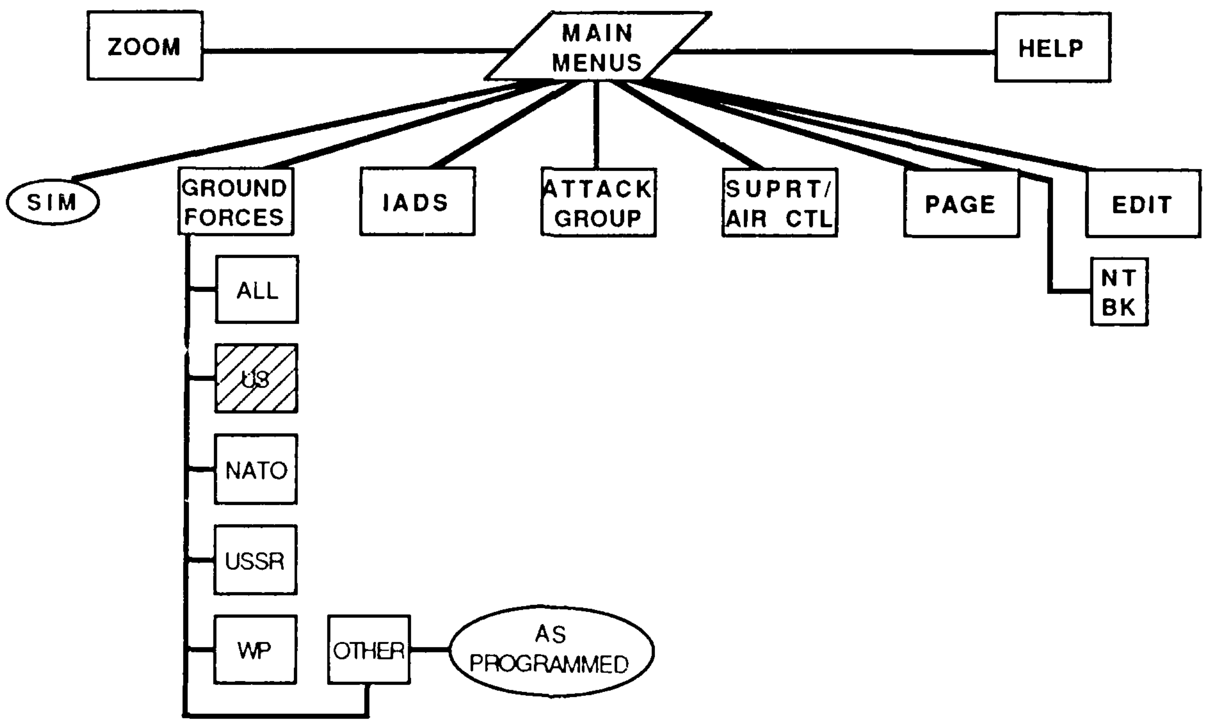
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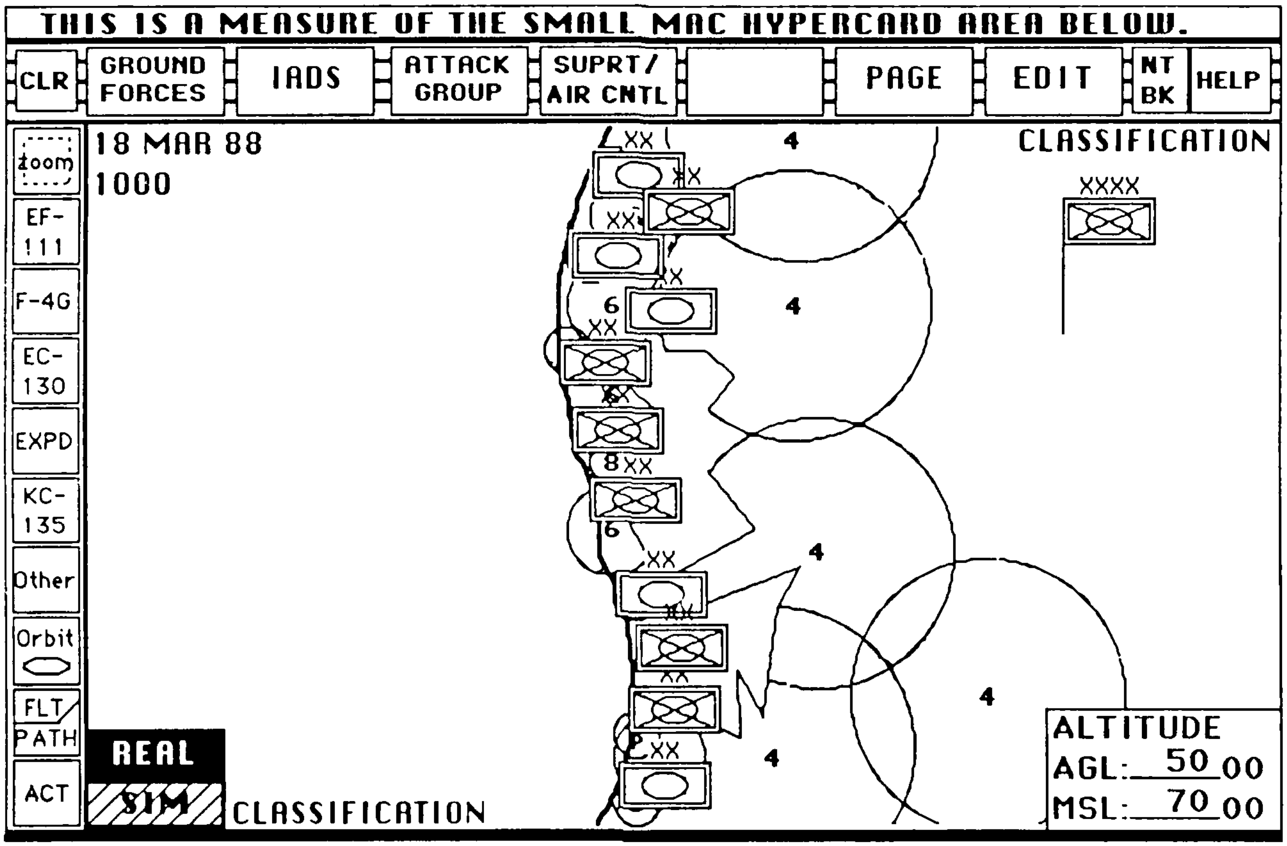
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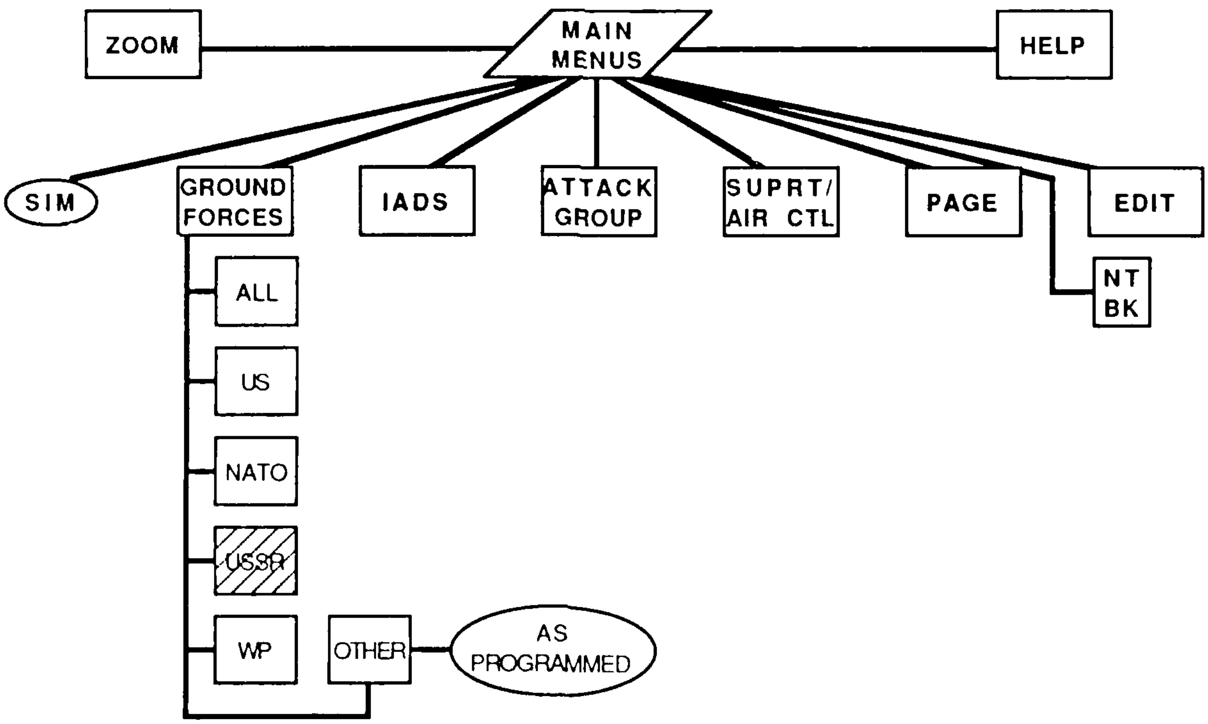
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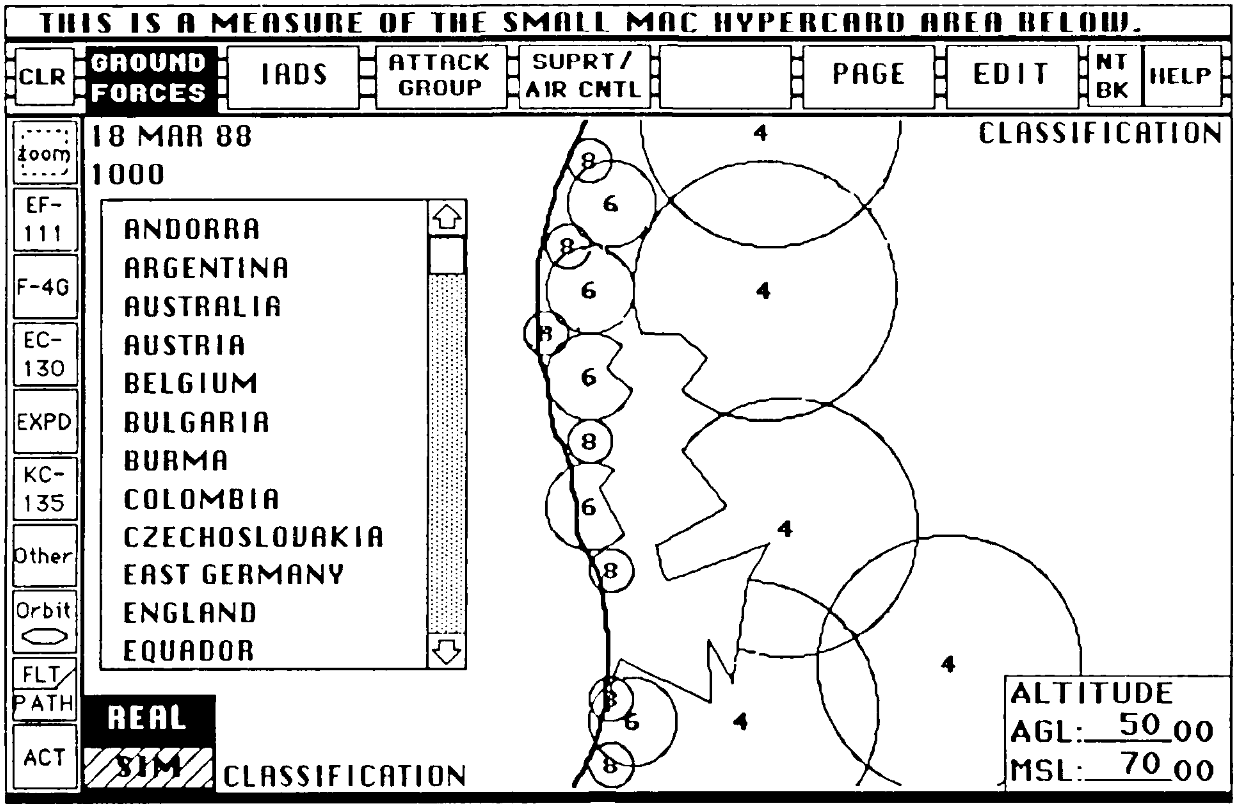
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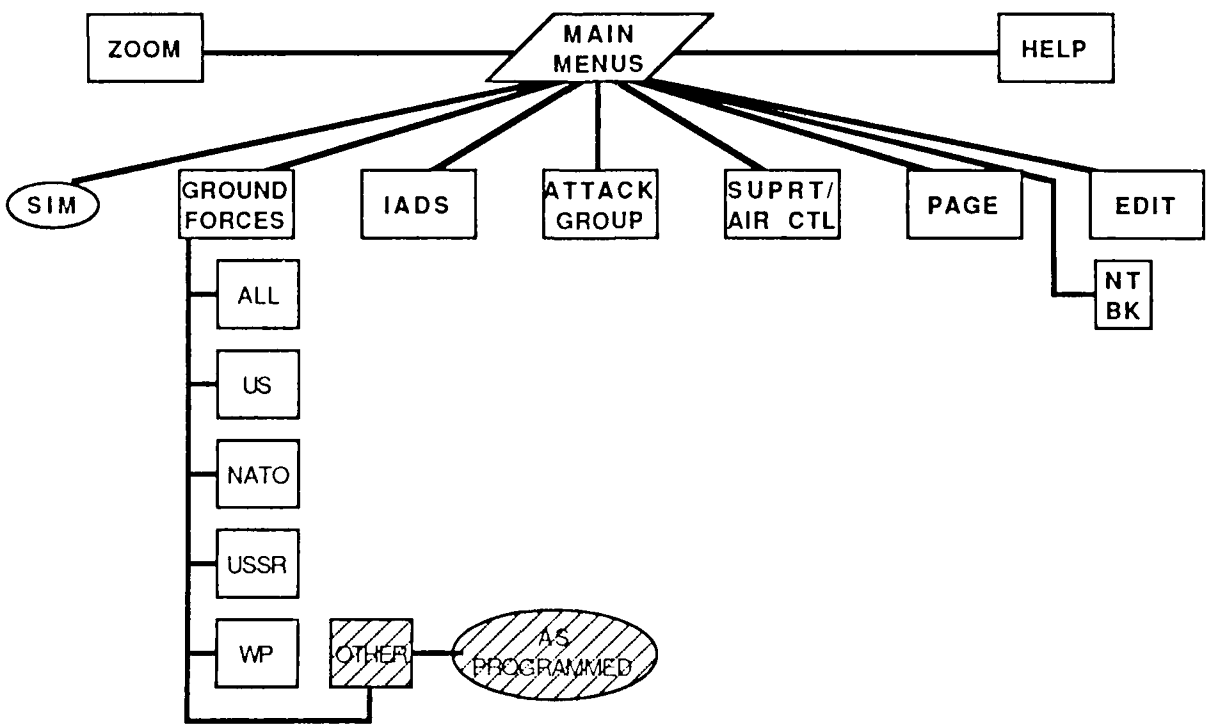
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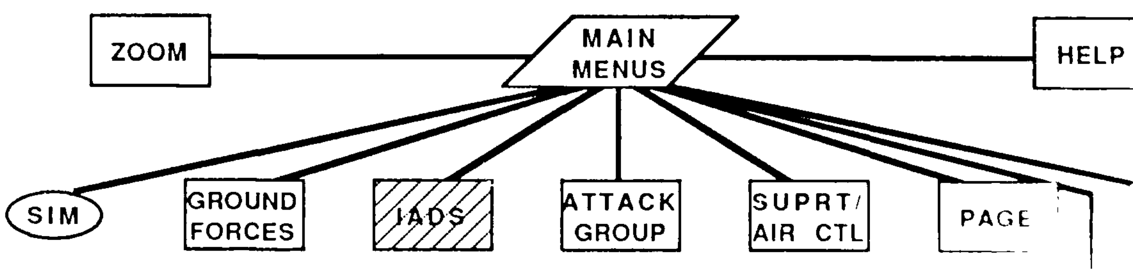
IADS (Integrated Air Defense System)

The IADS menu control enables the user to request various components and combinations of components of the enemy integrated air defense system. This allows the differentiation between air and ground threats, fixed or mobile ground threats, and SAM or AAA systems. It also allow the user to display the ranges of the threat systems' radars and/or weapons ranges after they have been affected by terrain, jamming, weather, or other factors. Additionally, the IADS menu allows the presentation of those enemy radar systems which are used to supply the threat system with acquisition information. The page can also show the C2 connectivity between the units if the IADS. The presentation will give a projected degradation of these connections based on simulation models which use the position of the sites, terrain, weather, type countermeasure being used, the location of the countermeasure being used, and mode of the enemy radar to name the major factors. See the HELP file for a thorough explanation of the representations, operations, memory aids, and control mechanism available to the user on these pages.



AD-A190 762 DESIGN REQUIREMENTS FOR A DECISION SUPPORT SYSTEM FOR THE DYNAMIC RETASKI (U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGI C D FLETCHER 2/3

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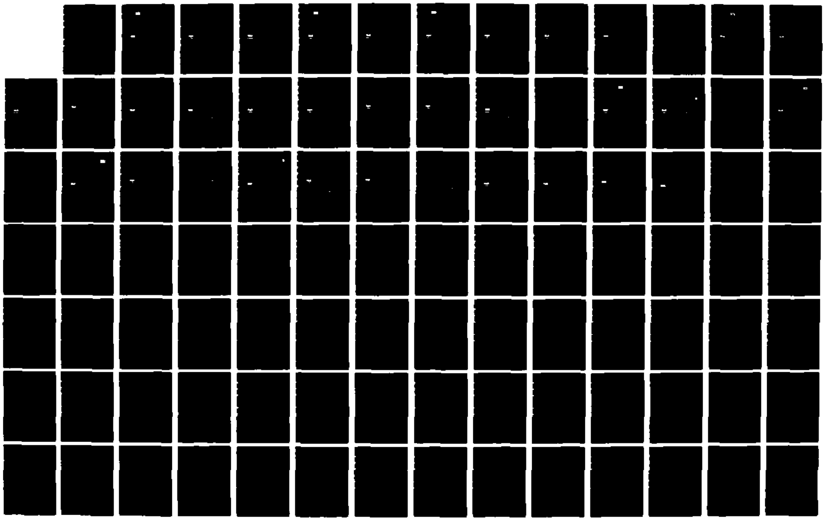

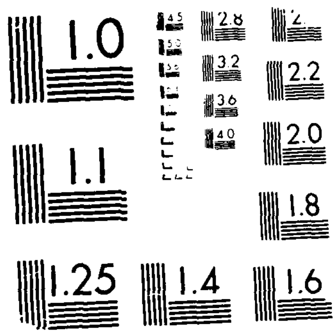

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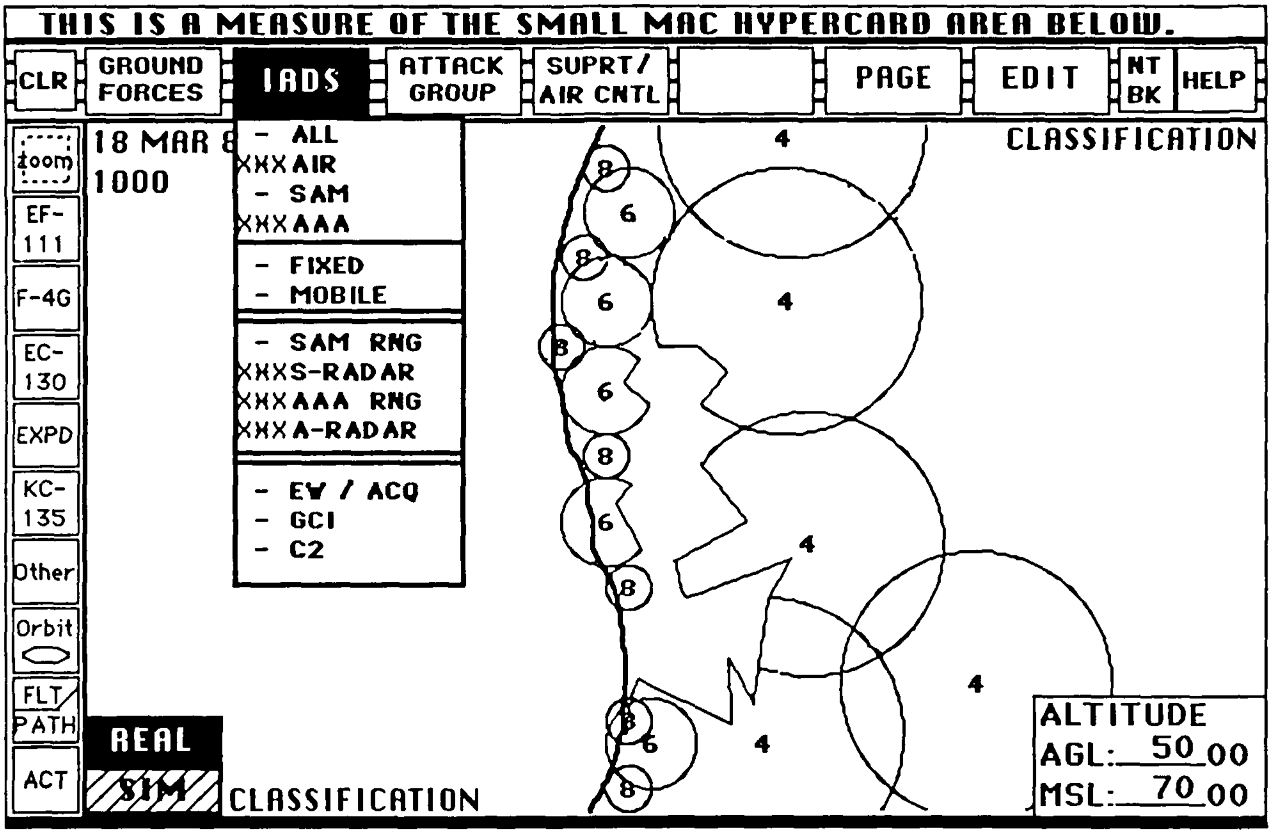

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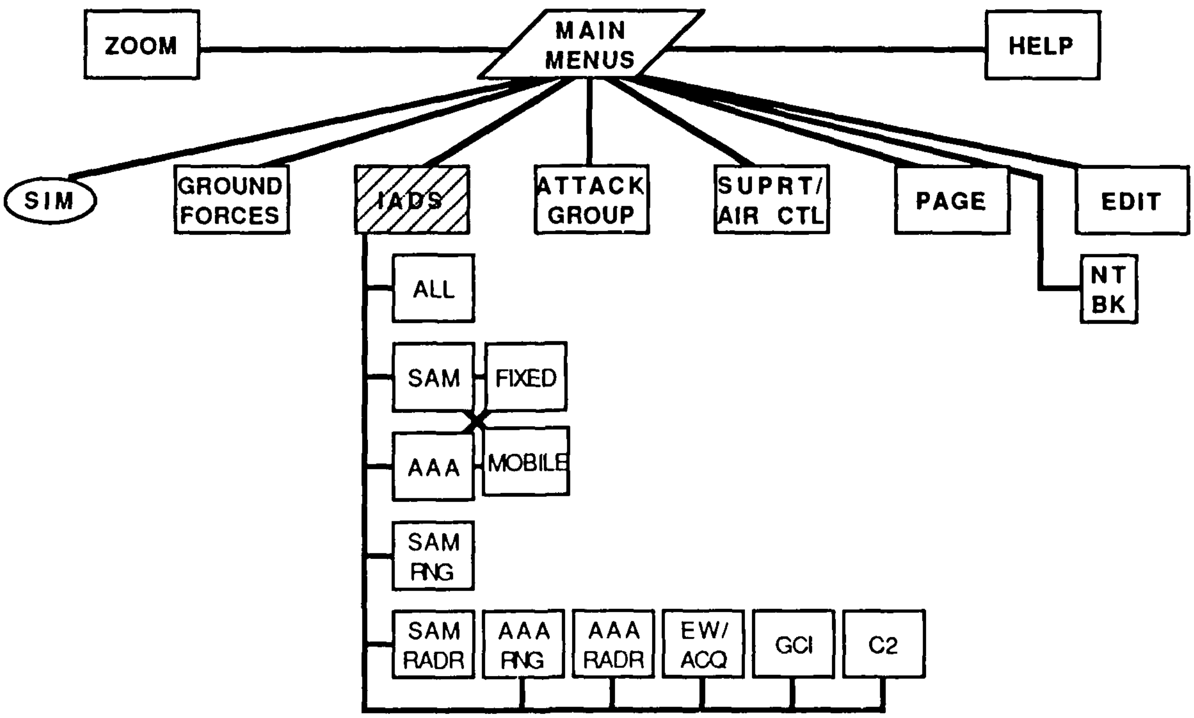

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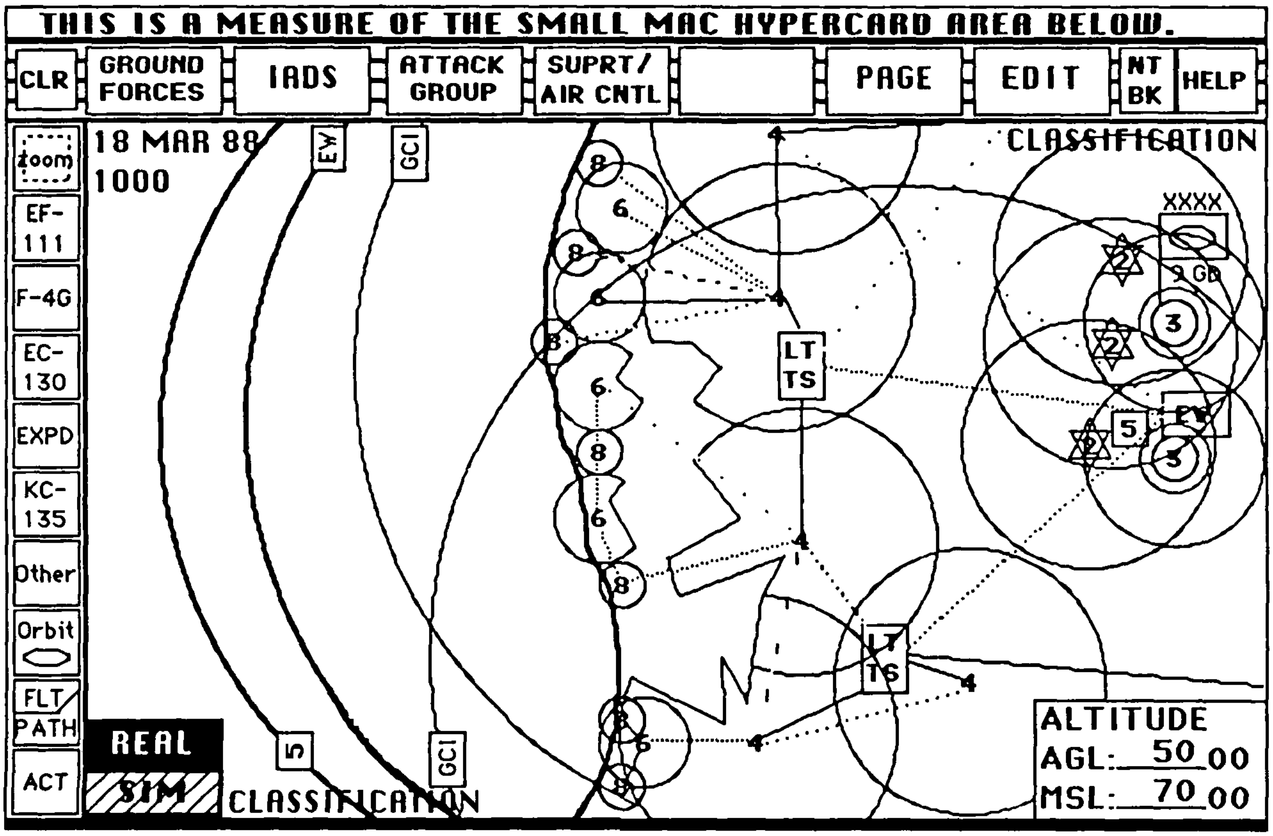
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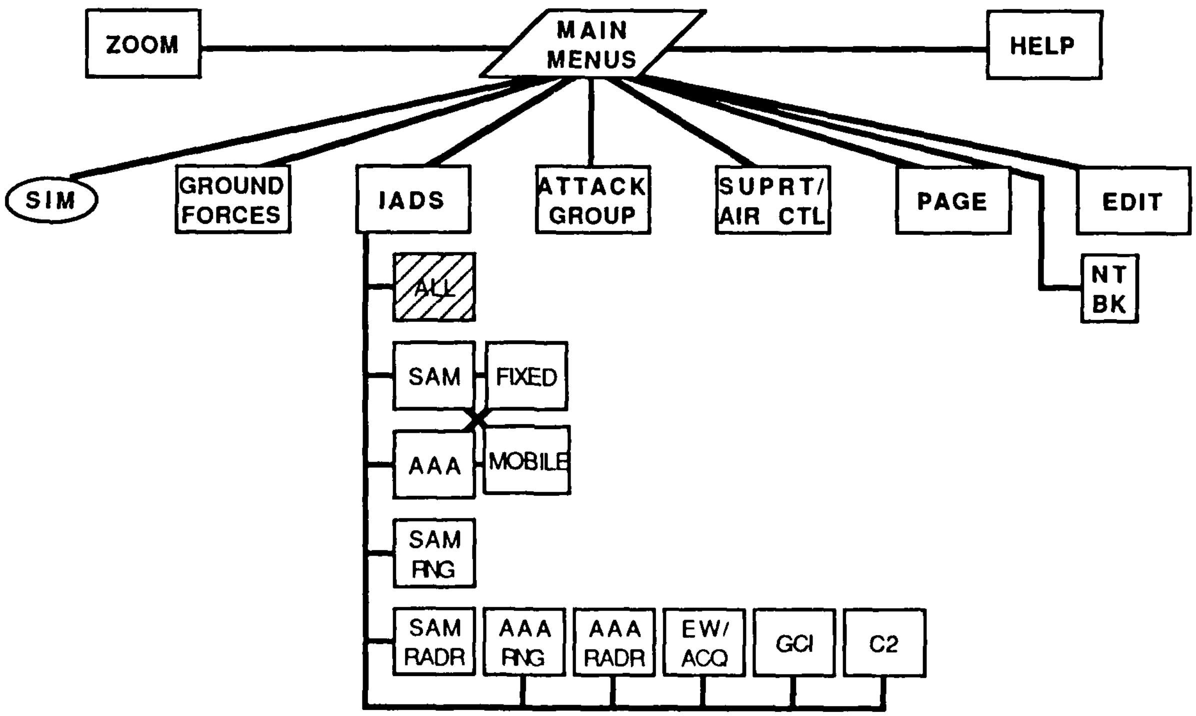
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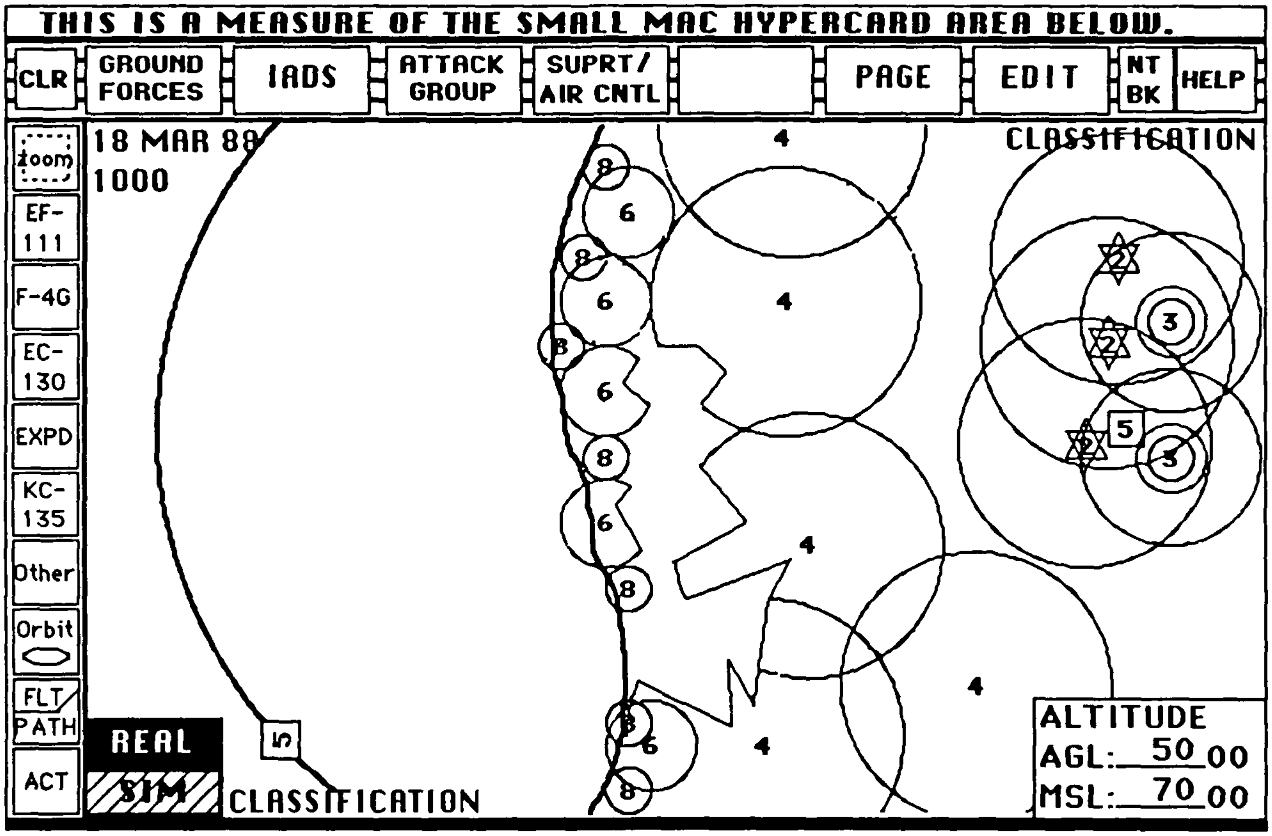
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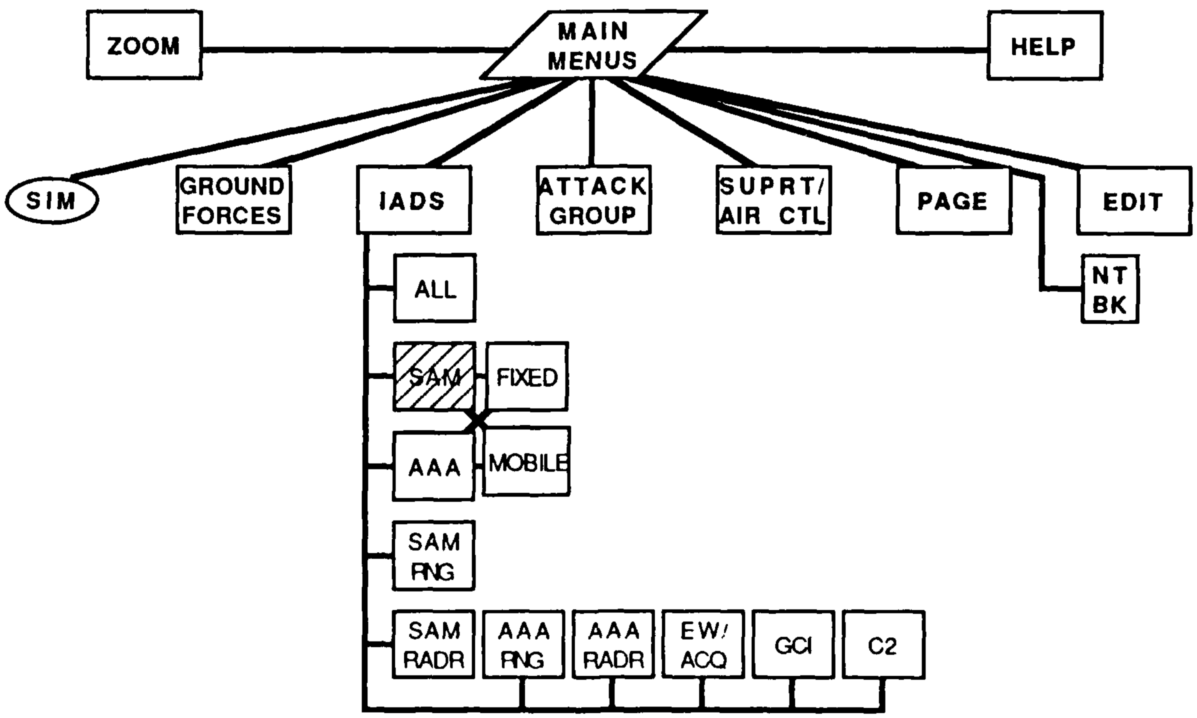
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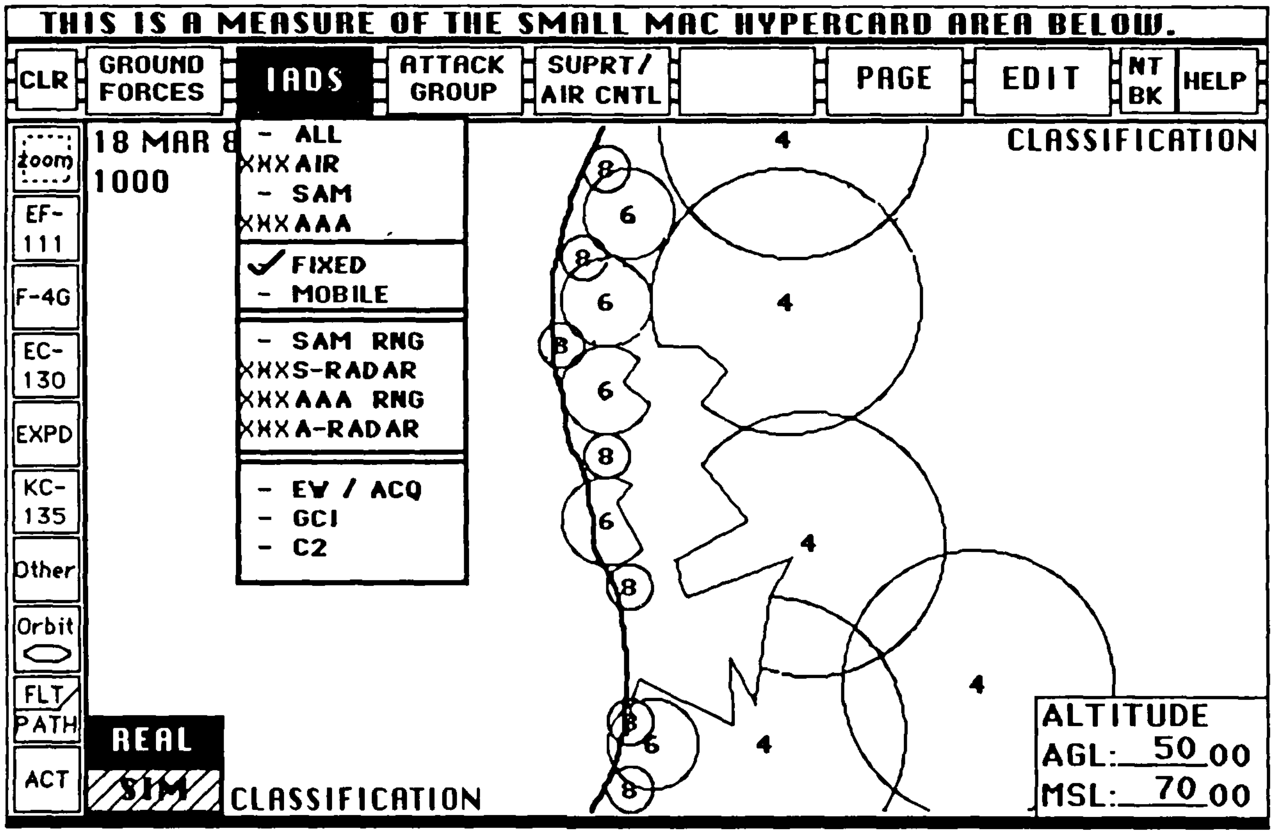
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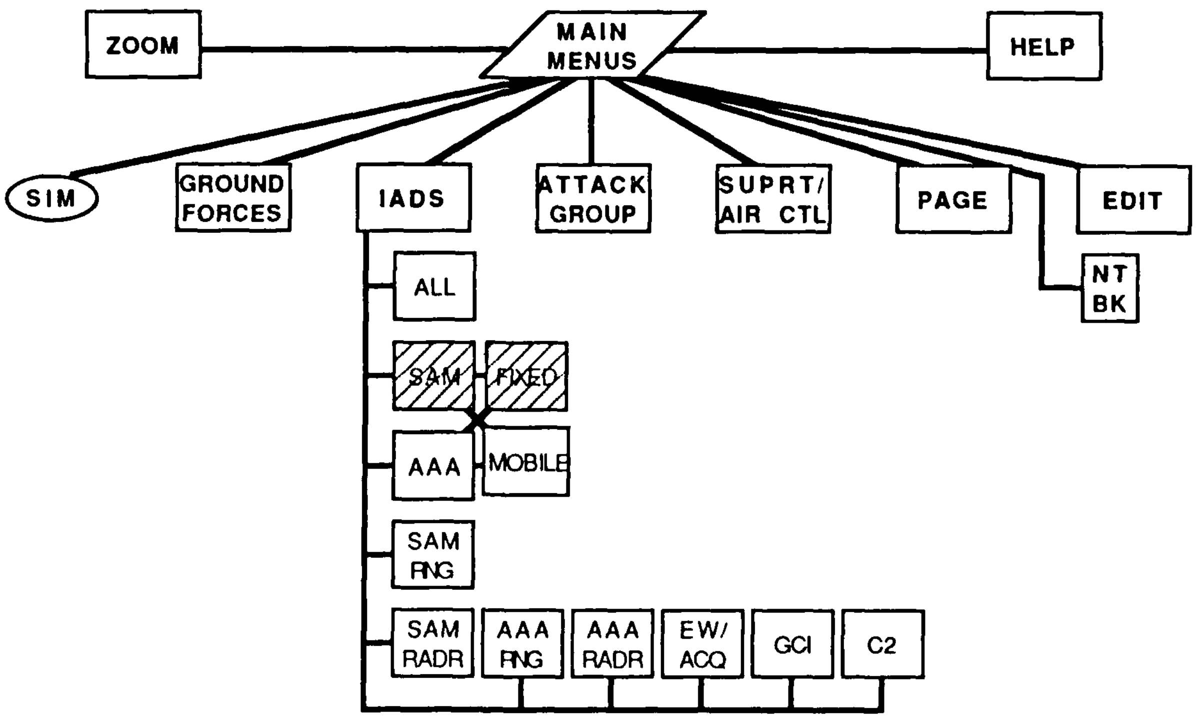
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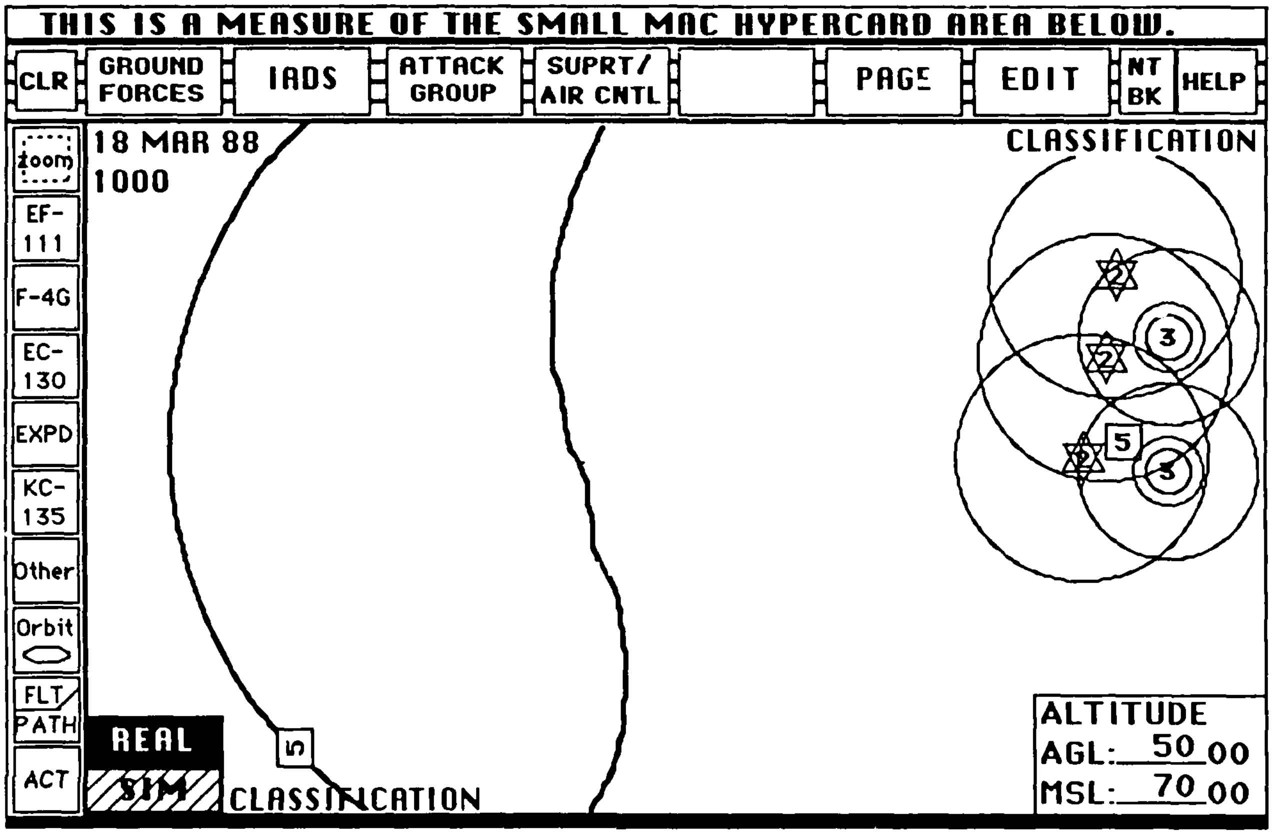
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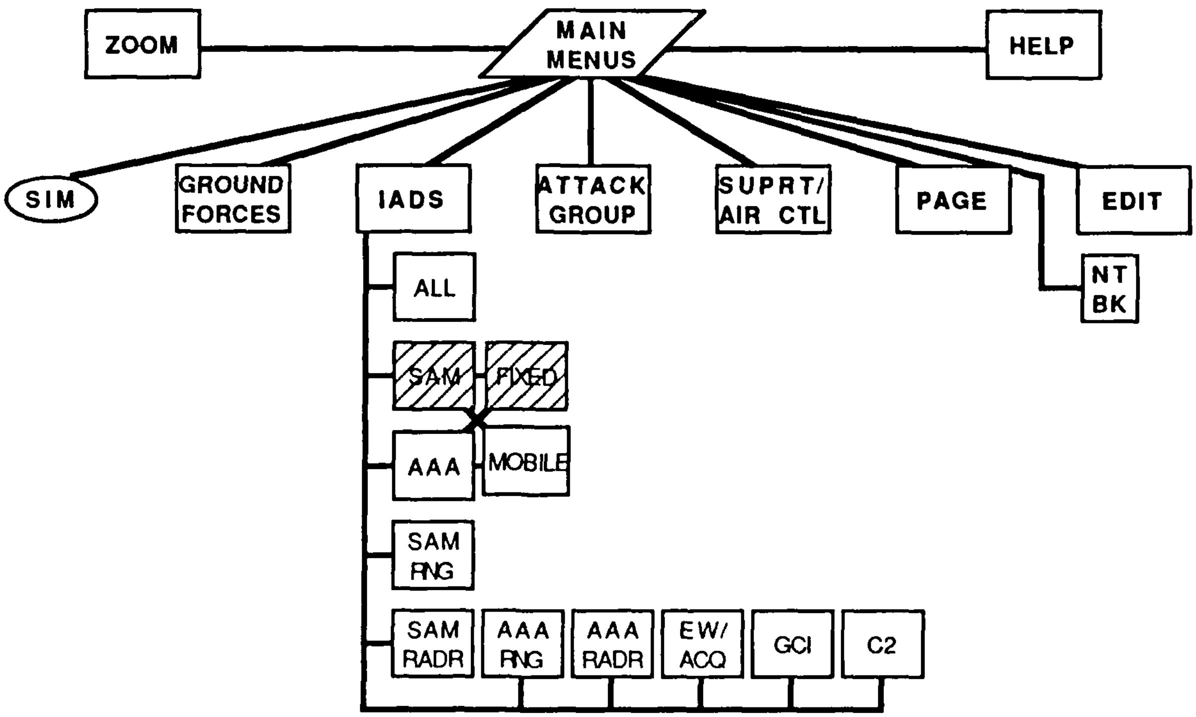
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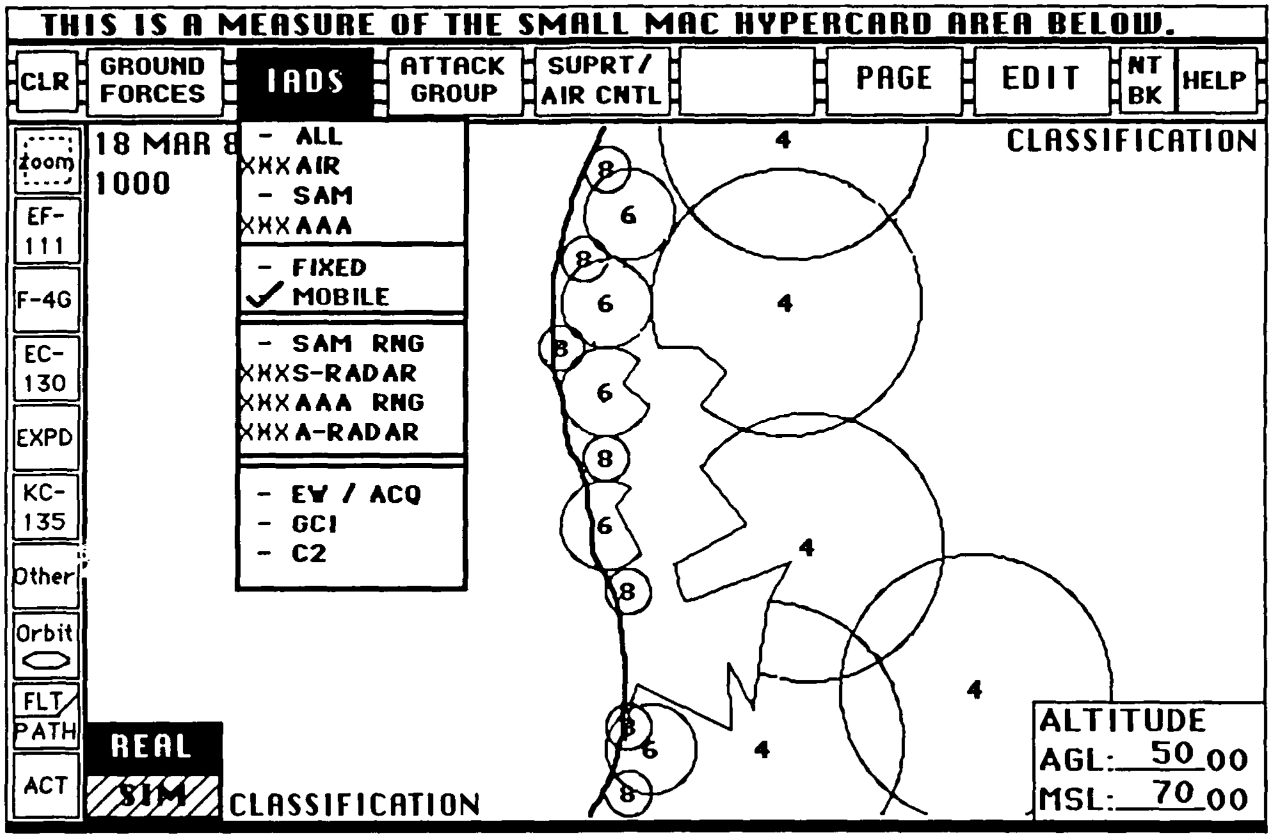
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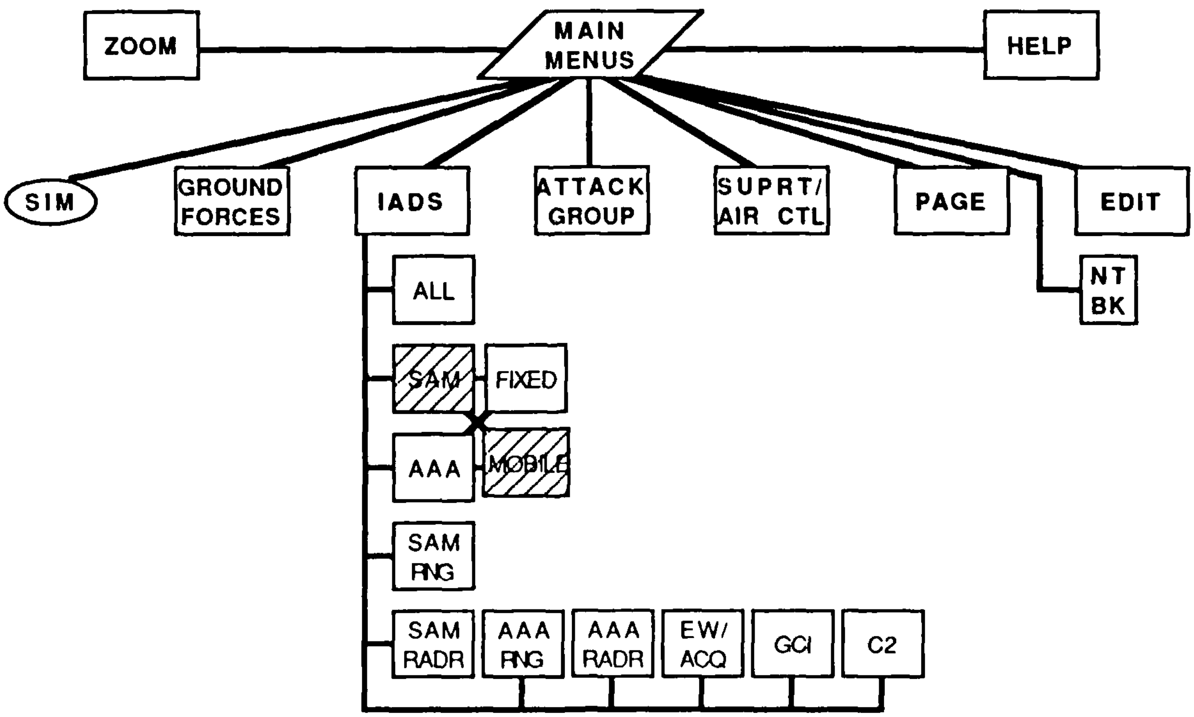
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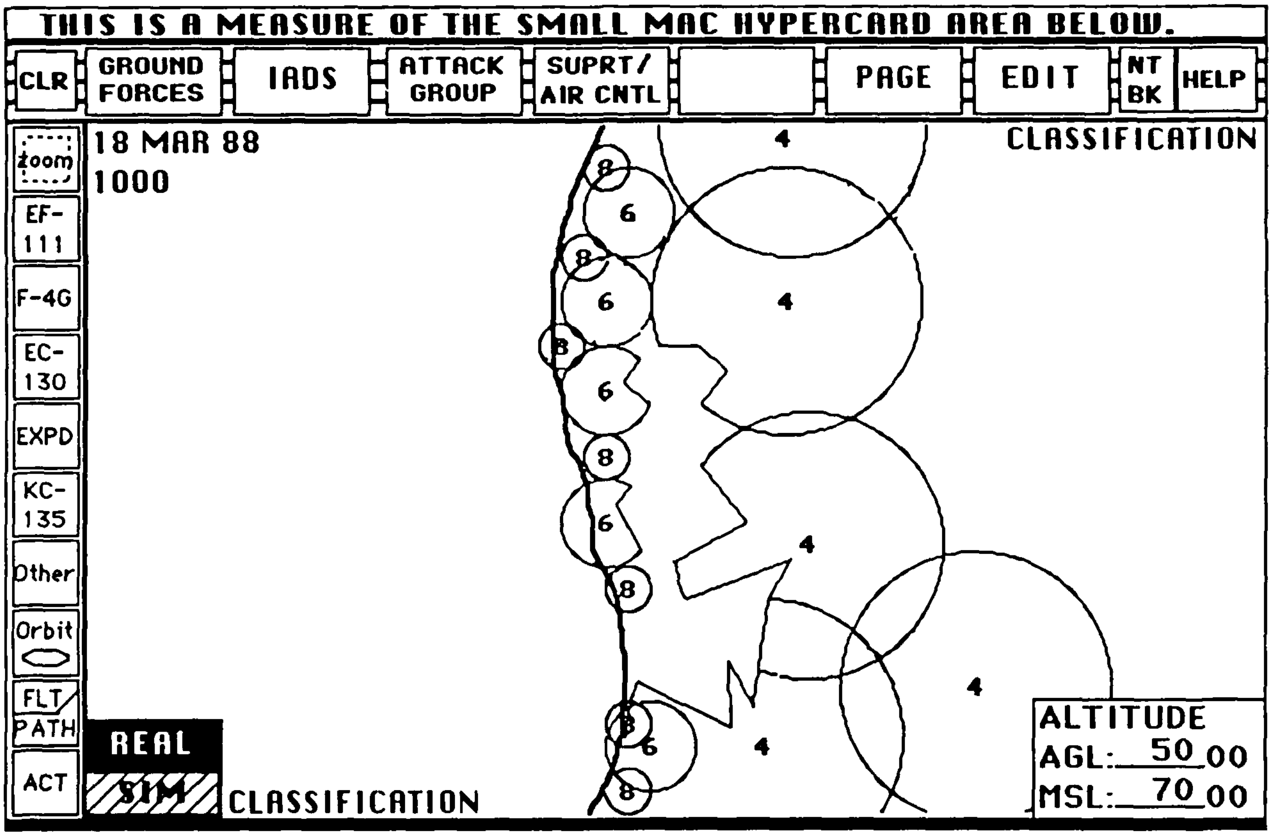
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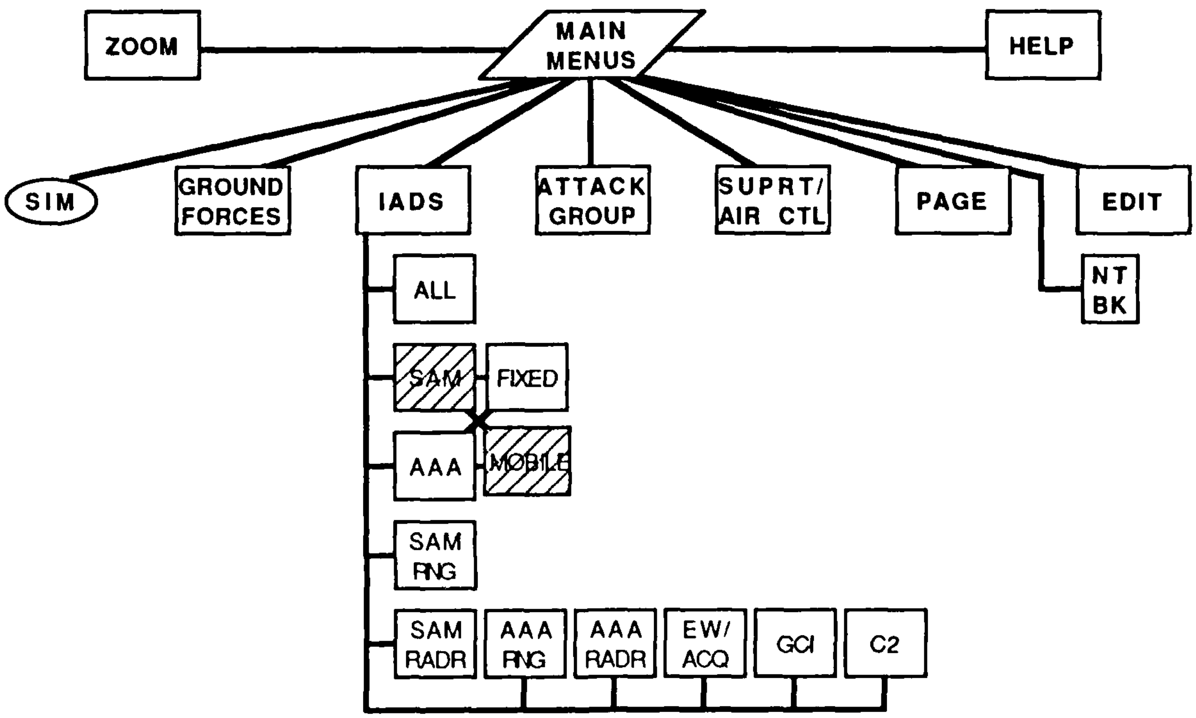
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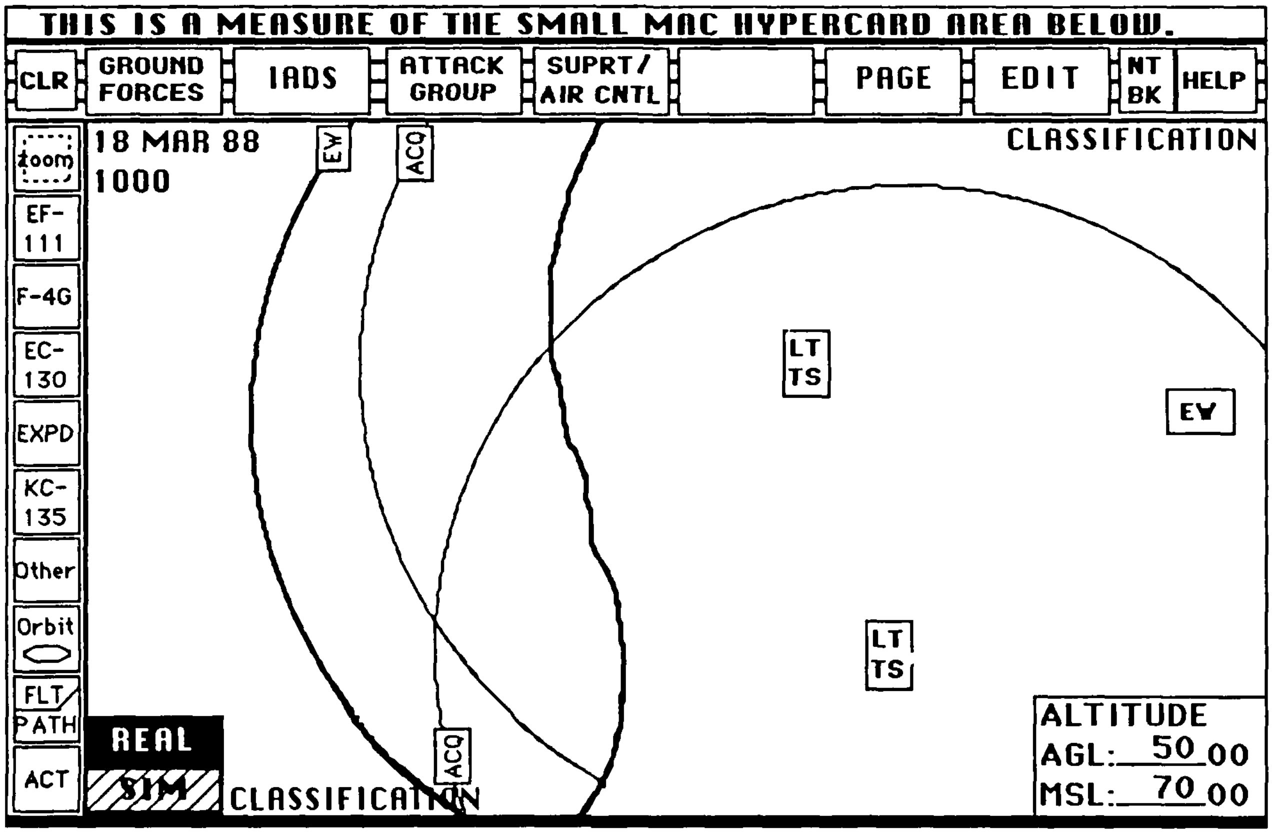
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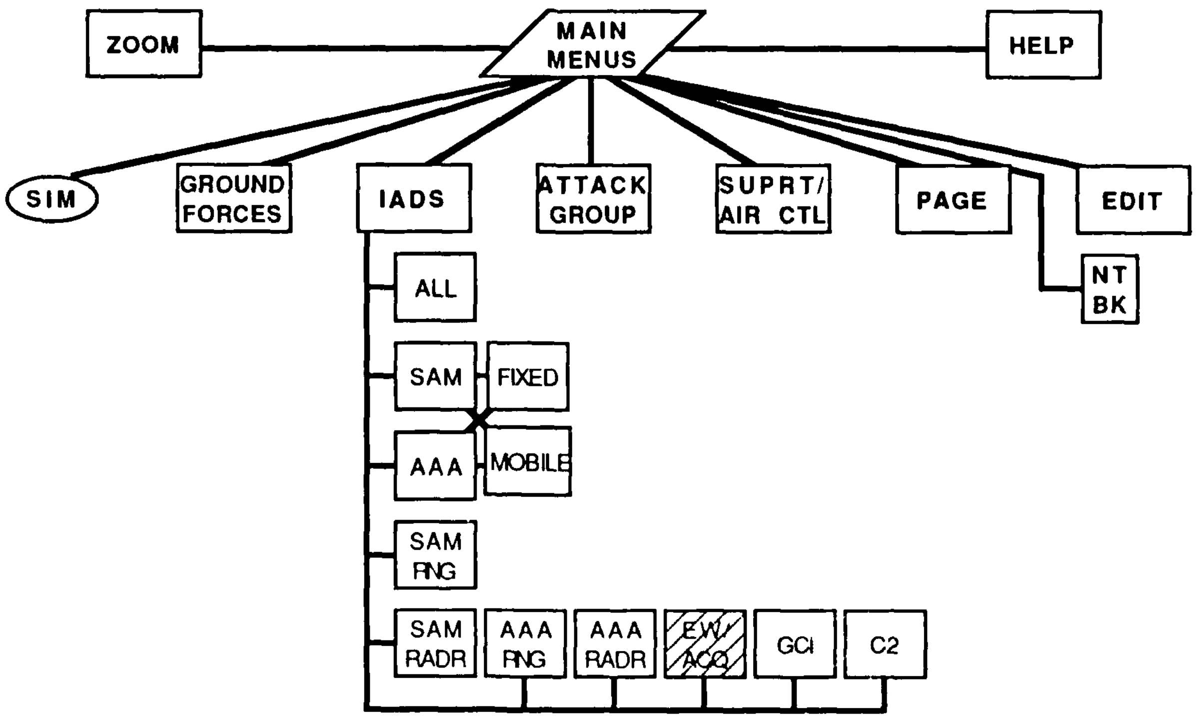
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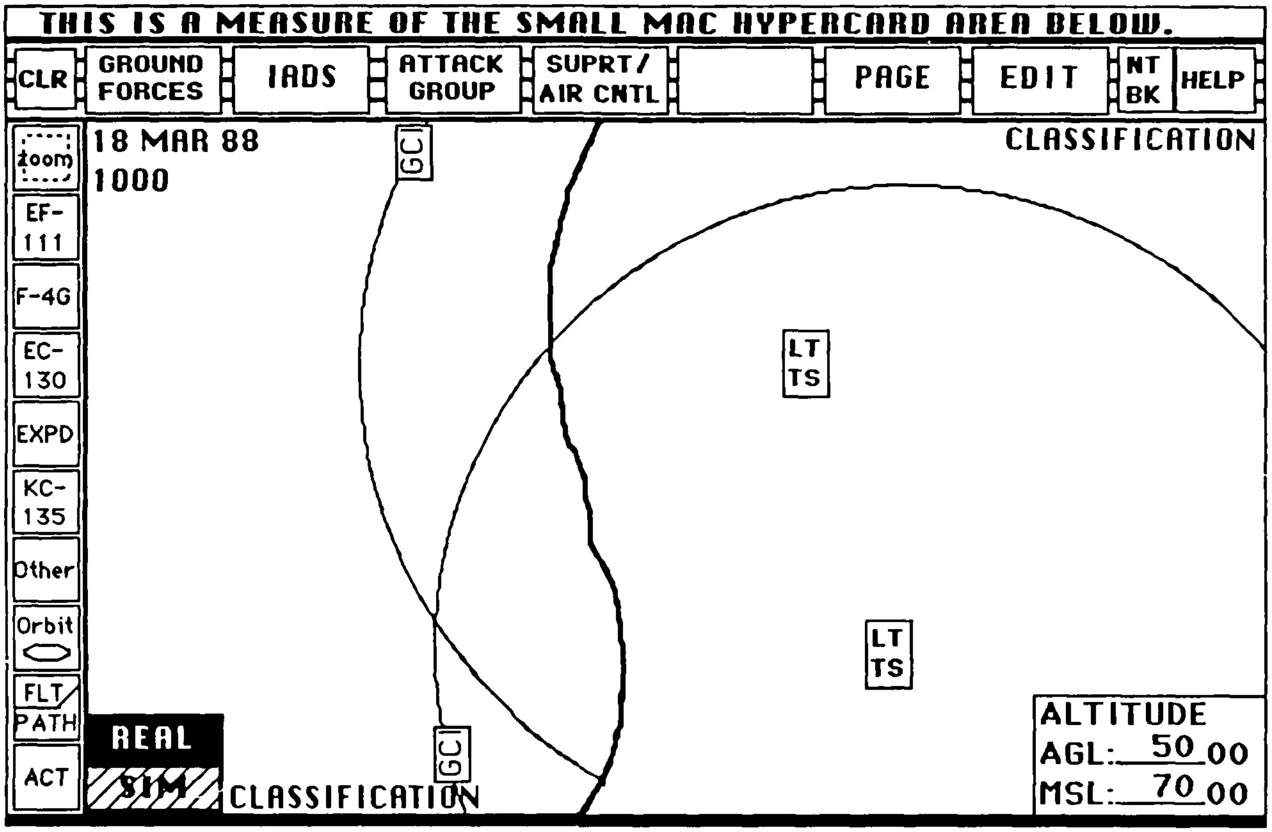

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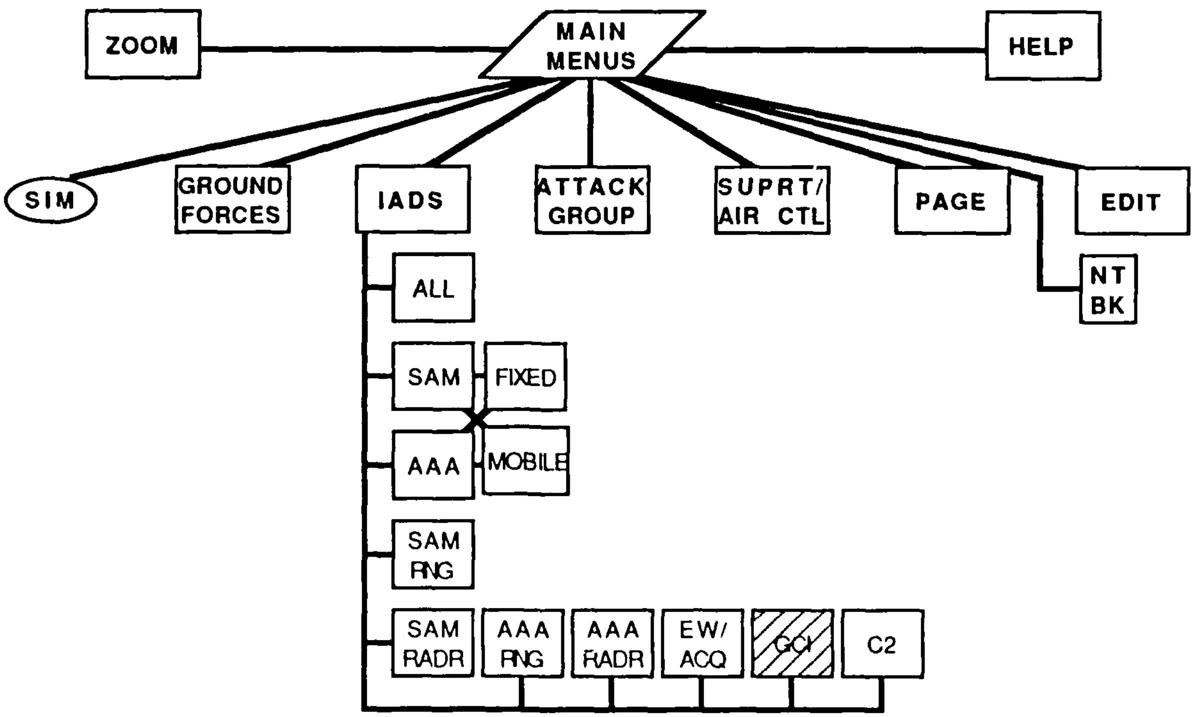
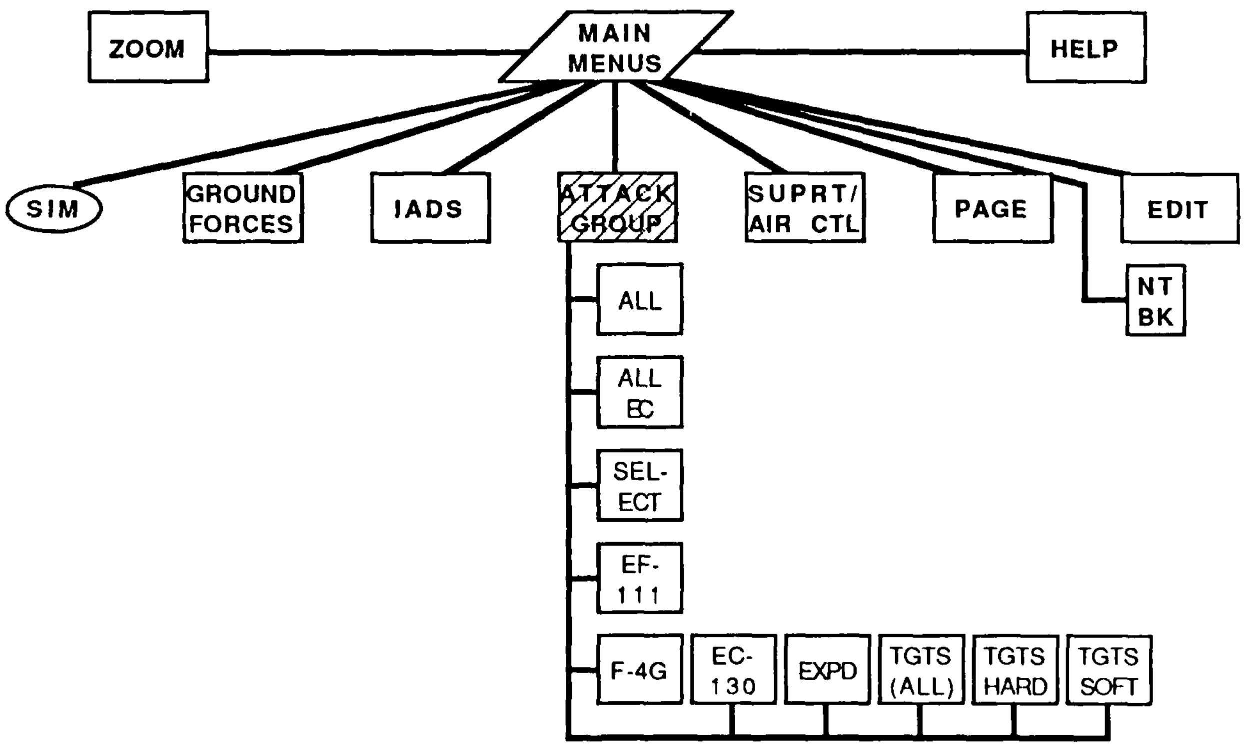
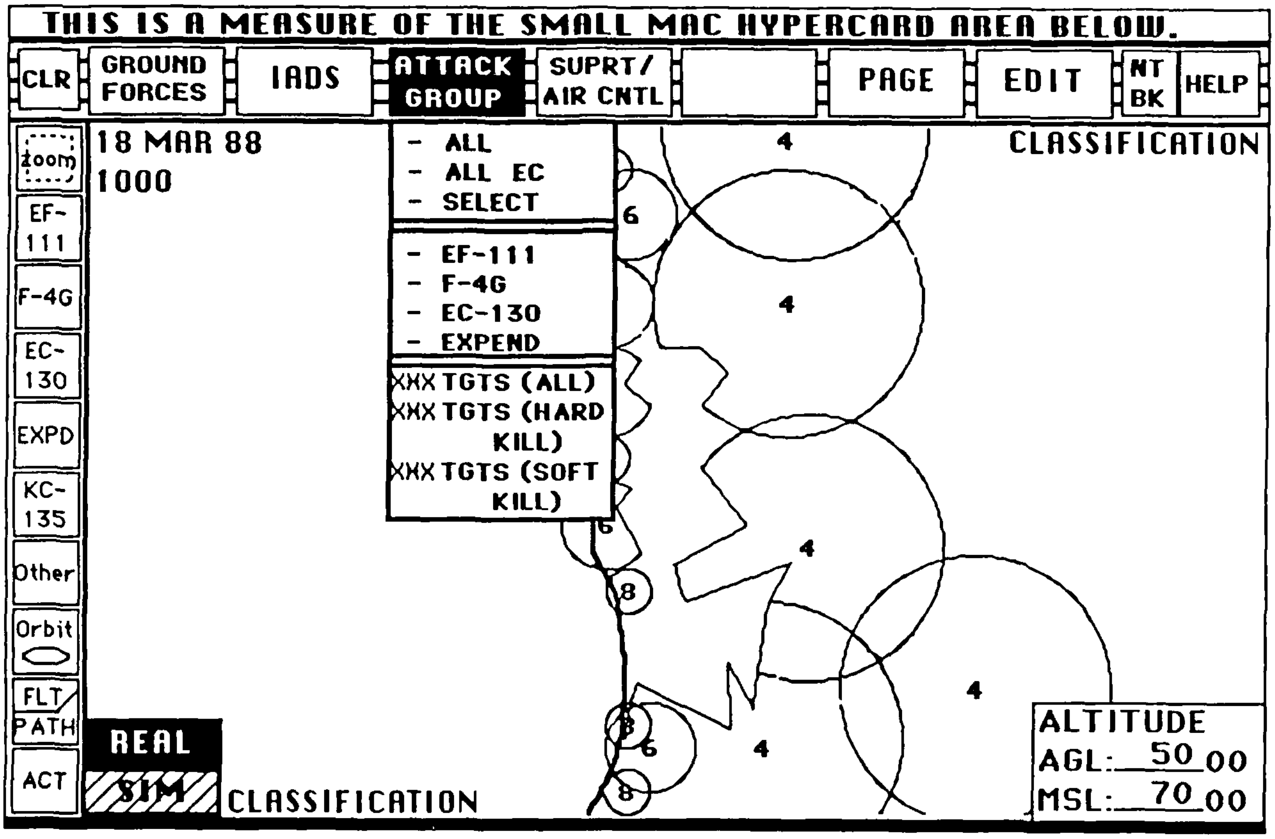


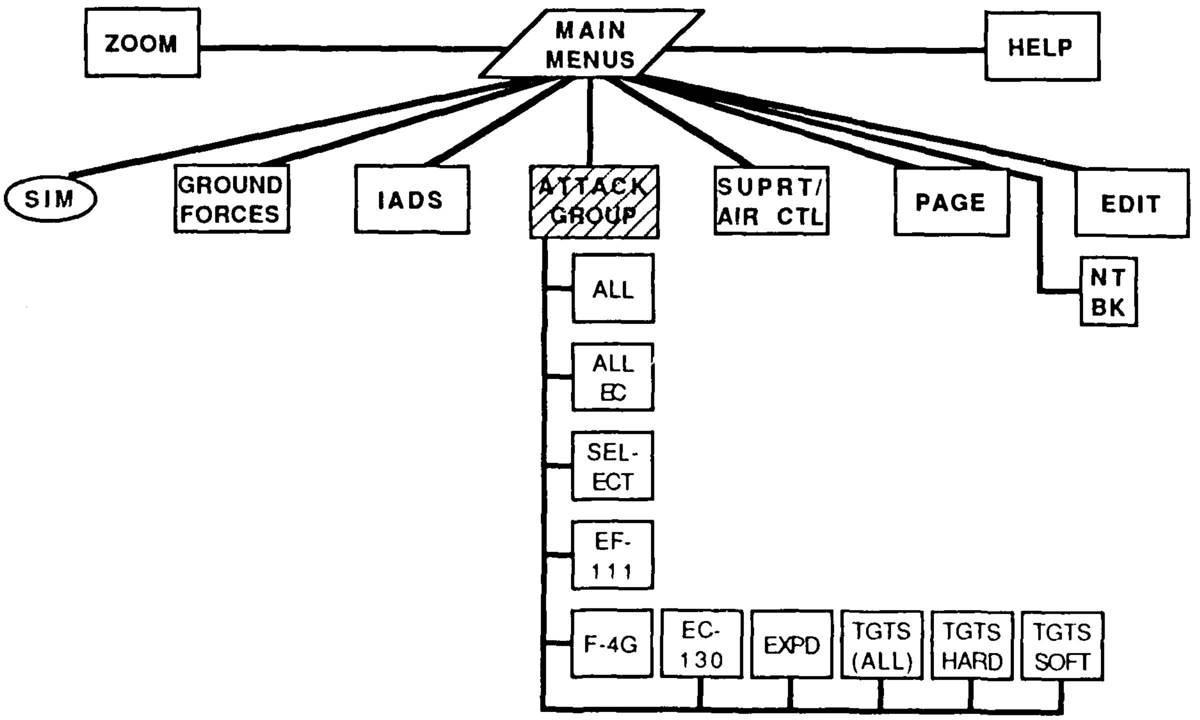
ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
SAM
FIXED
AAA
MOBILE
SAM RNG
SAM RADR
AAA RNG
AAA RADR
EW/ ACQ
GCI
C2

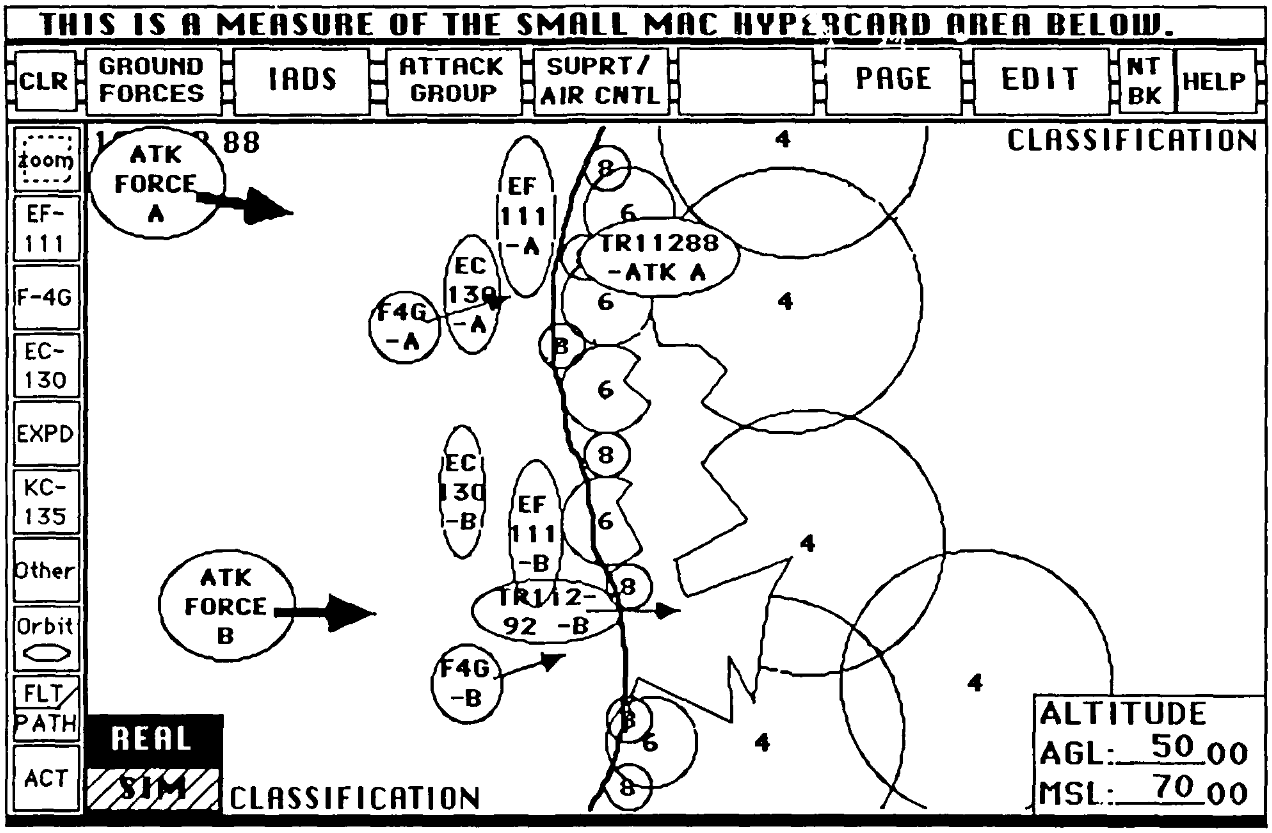
Attack Group

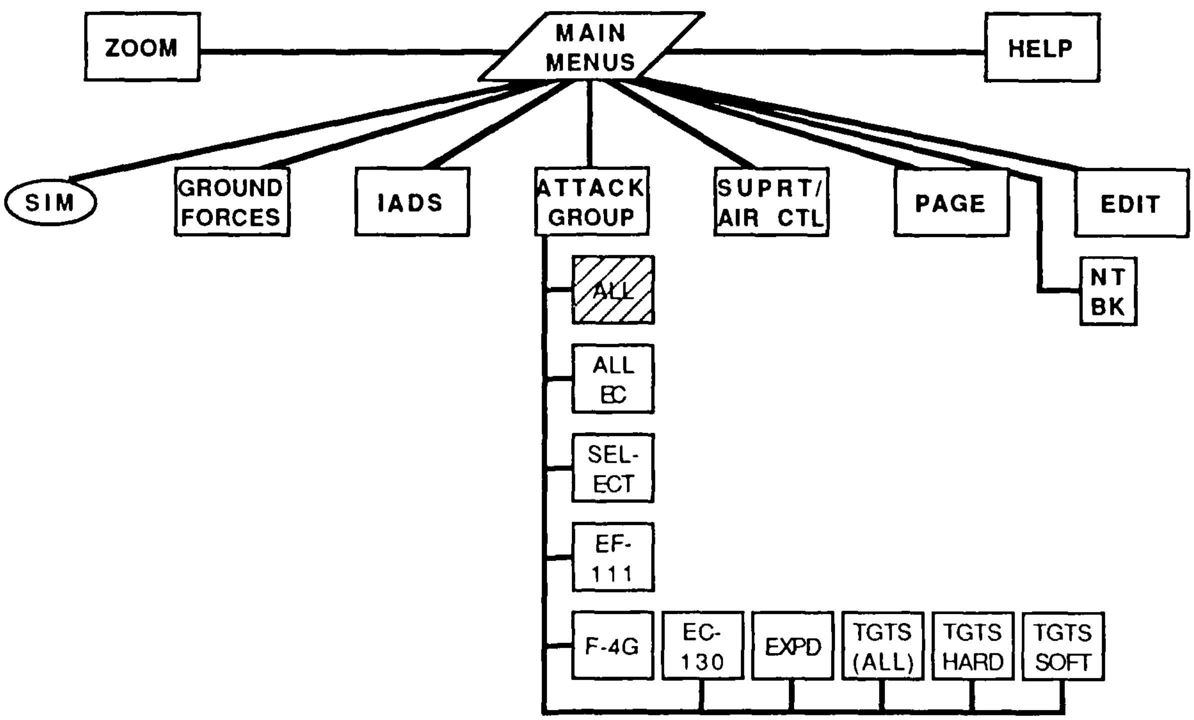
The ATTACK GROUP menu control enables the user to view various combinations of information concerning both the friendly air forces and the tasked targets. This covers direct attack forces, support forces such as the EC and air refueling forces, targets selected to be physically destroyed (hard kill), and targets selected for neutralization through other than physical destruction such as through the use of ECM (electronic countermeasures). See the HELP file for a thorough explanation of the representations, operations, memory aids, and control mechanism available to the user on these pages.

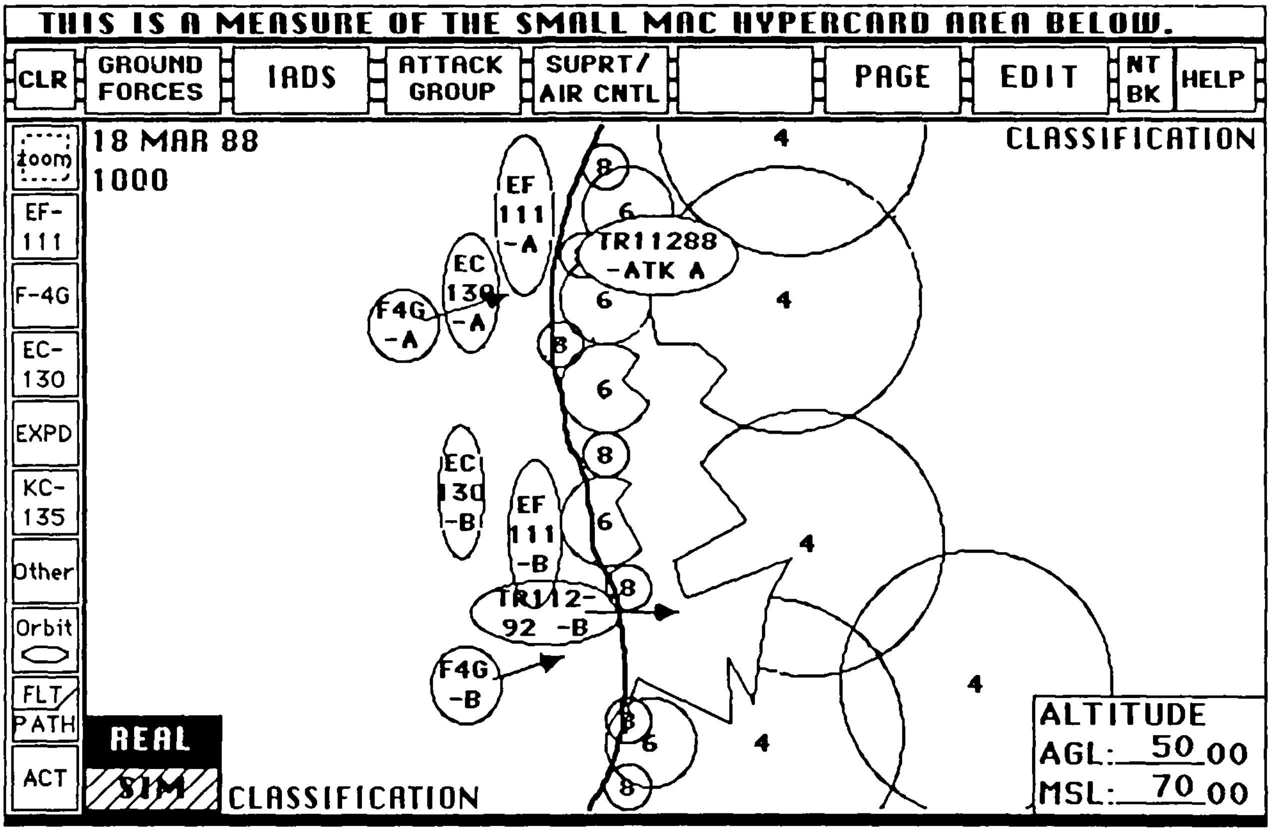



THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
- ALL
- ALL EC
- SELECT
- EF-111
- F-4G
- EC-130
- EXPEND
XXX TGTS (ALL)
XXX TGTS (HARD KILL)
XXX TGTS (SOFT KILL)
CLASSIFICATION
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

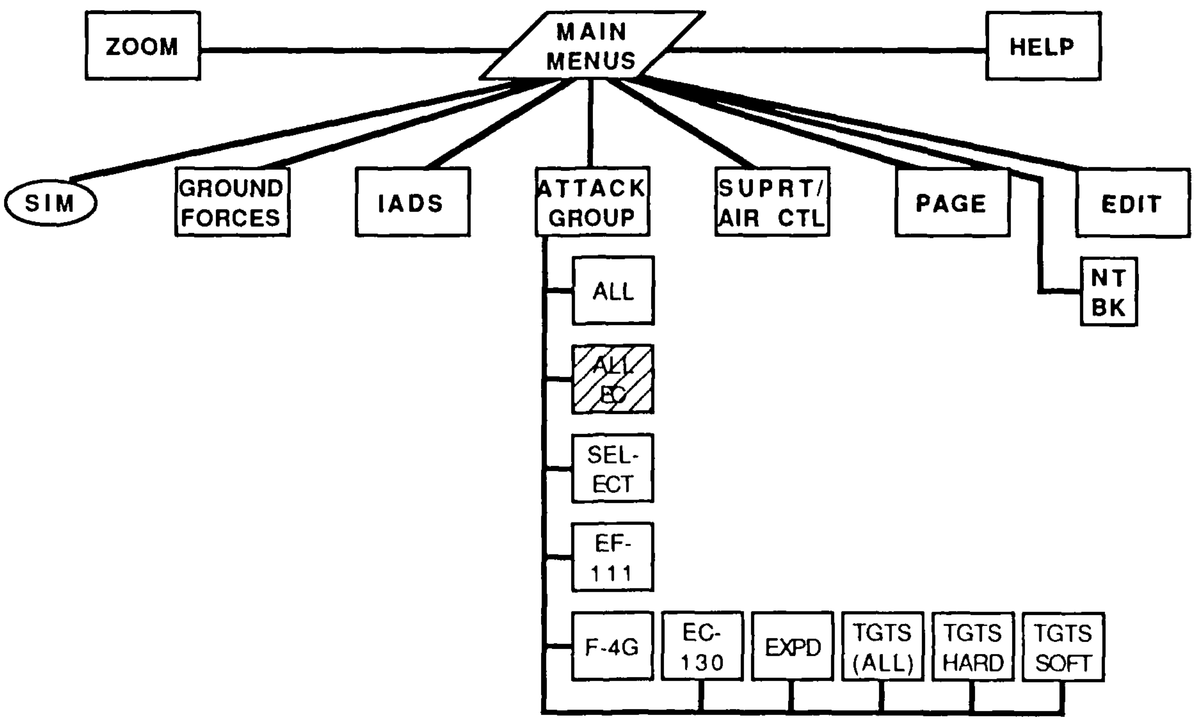

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
REAL
SIM
CLASSIFICATION
CLASSIFICATION
ATK FORCE A
ATK FORCE B
EF 111 -A
EC 130 -A
F4G -A
TR11288 -ATK A
EC 130 -B
EF 111 -B
TR112-92 -B
F4G -B
ALTITUDE
AGL: 50 00
MSL: 70 00

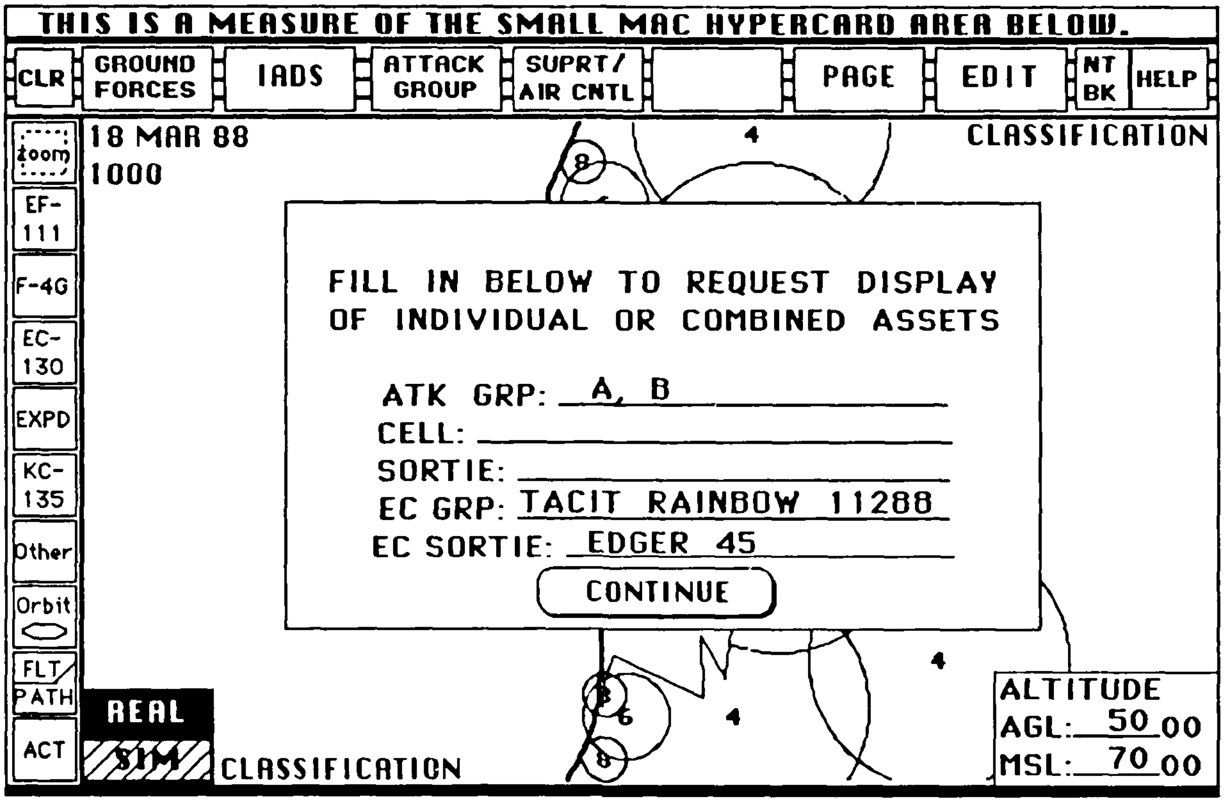

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT



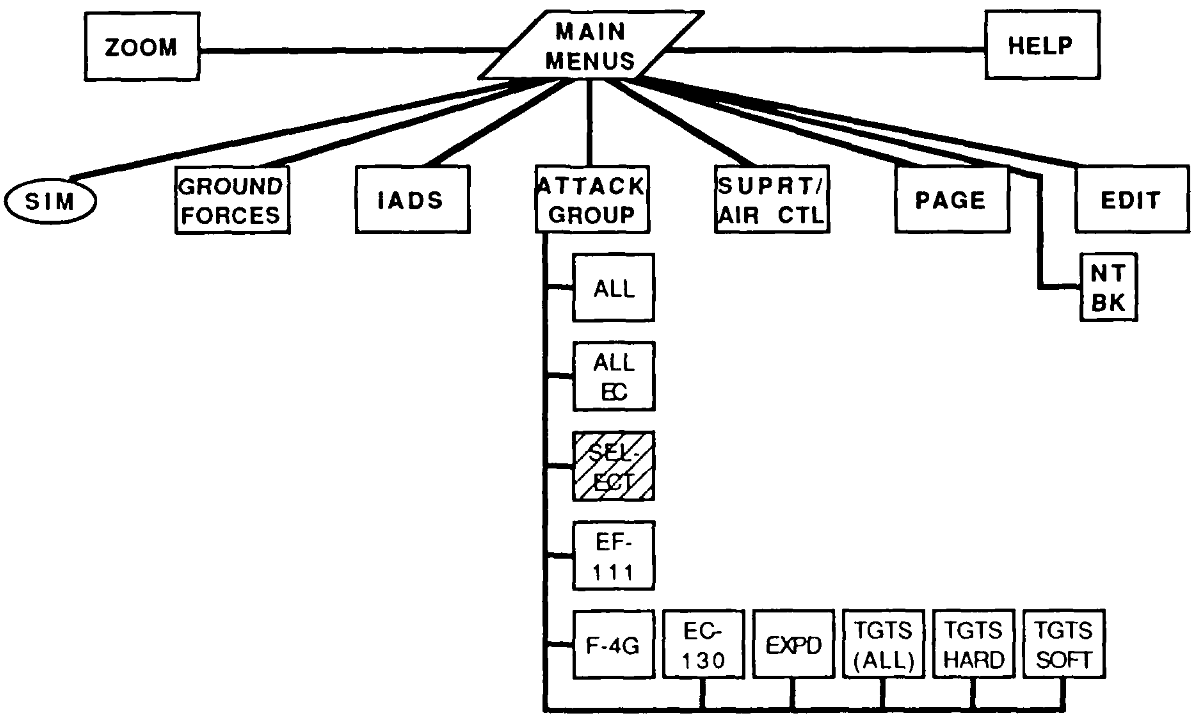
THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
EF 111 -A
EC 130 -A
F4G -A
TR11288 -ATK A
EC 130 -B
EF 111 -B
TR112-92 -B
F4G -B
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00



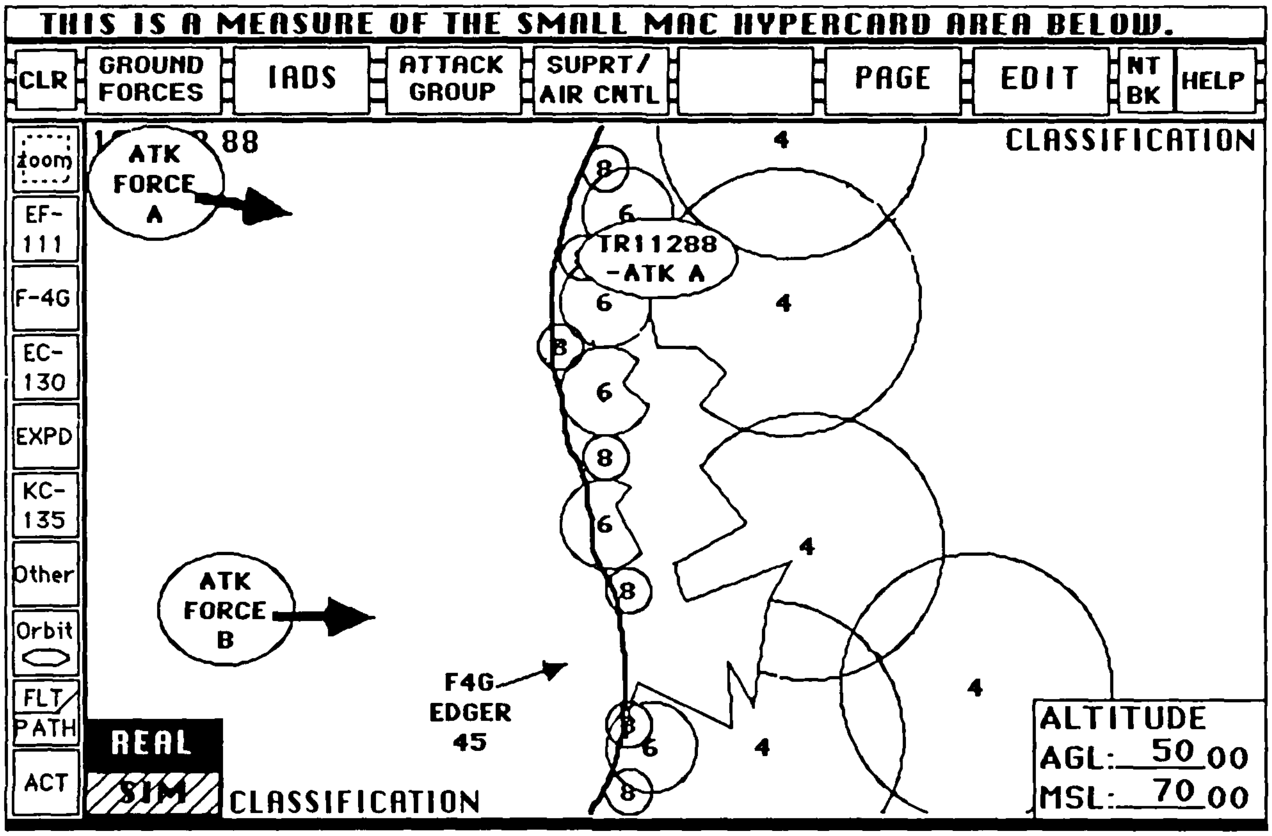
ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT

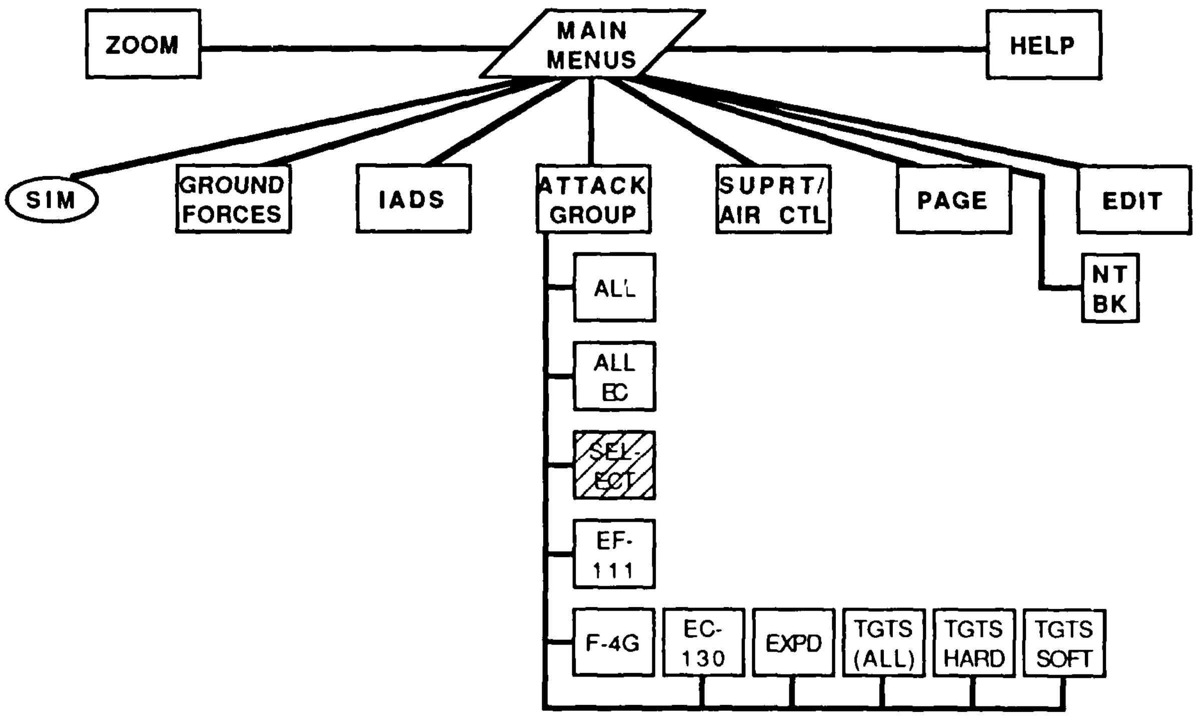


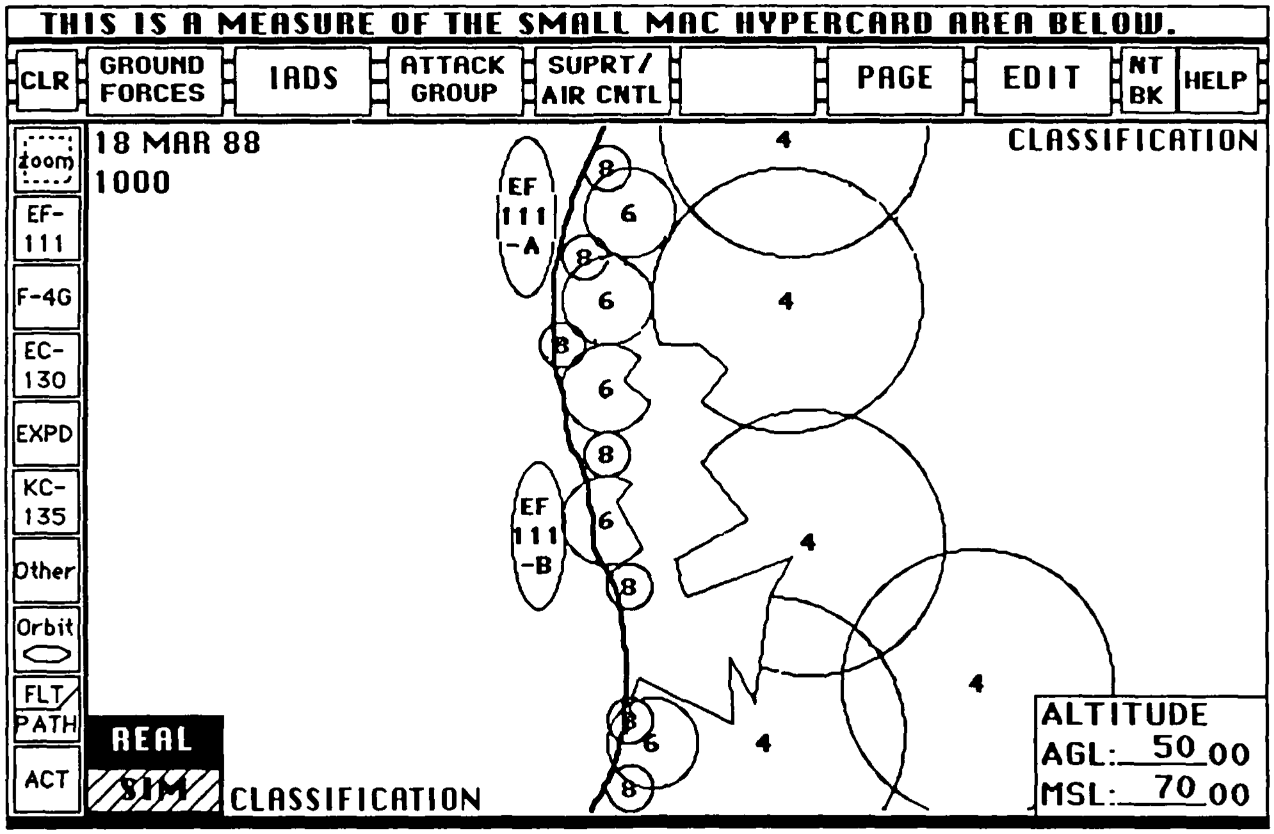
THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
FILL IN BELOW TO REQUEST DISPLAY OF INDIVIDUAL OR COMBINED ASSETS
ATK GRP: A, B
CELL:
SORTIE:
EC GRP: TACIT RAINBOW 11288
EC SORTIE: EDGER 45
CONTINUE
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

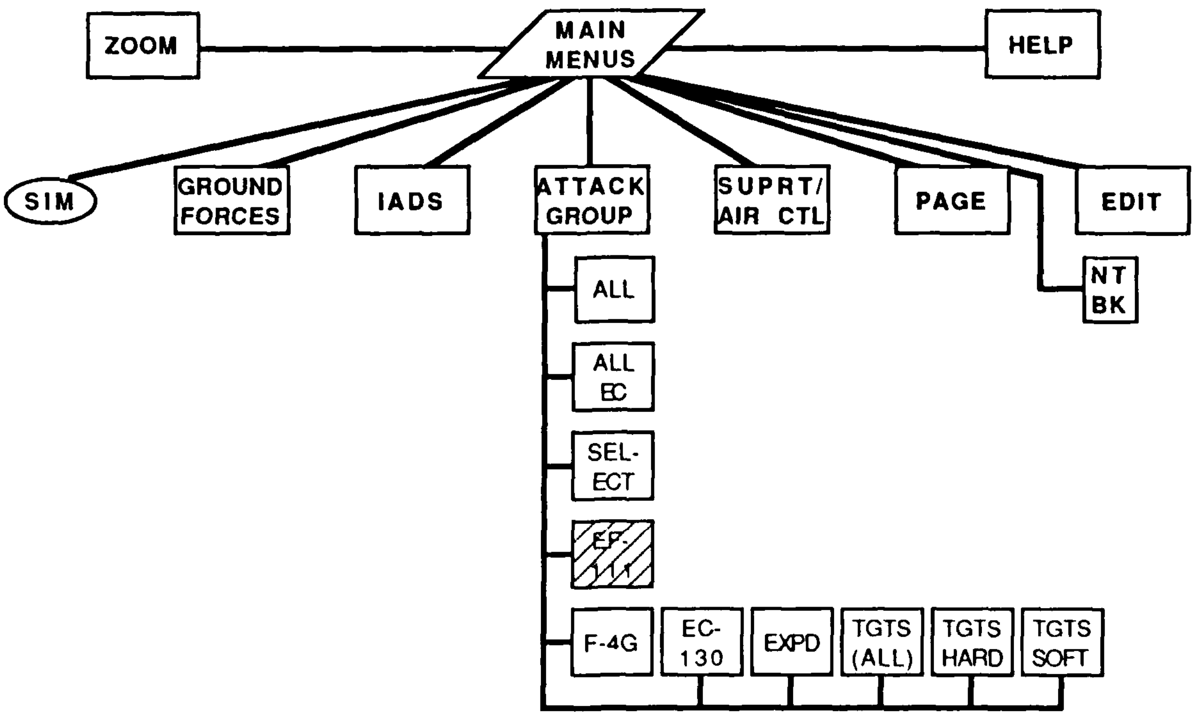


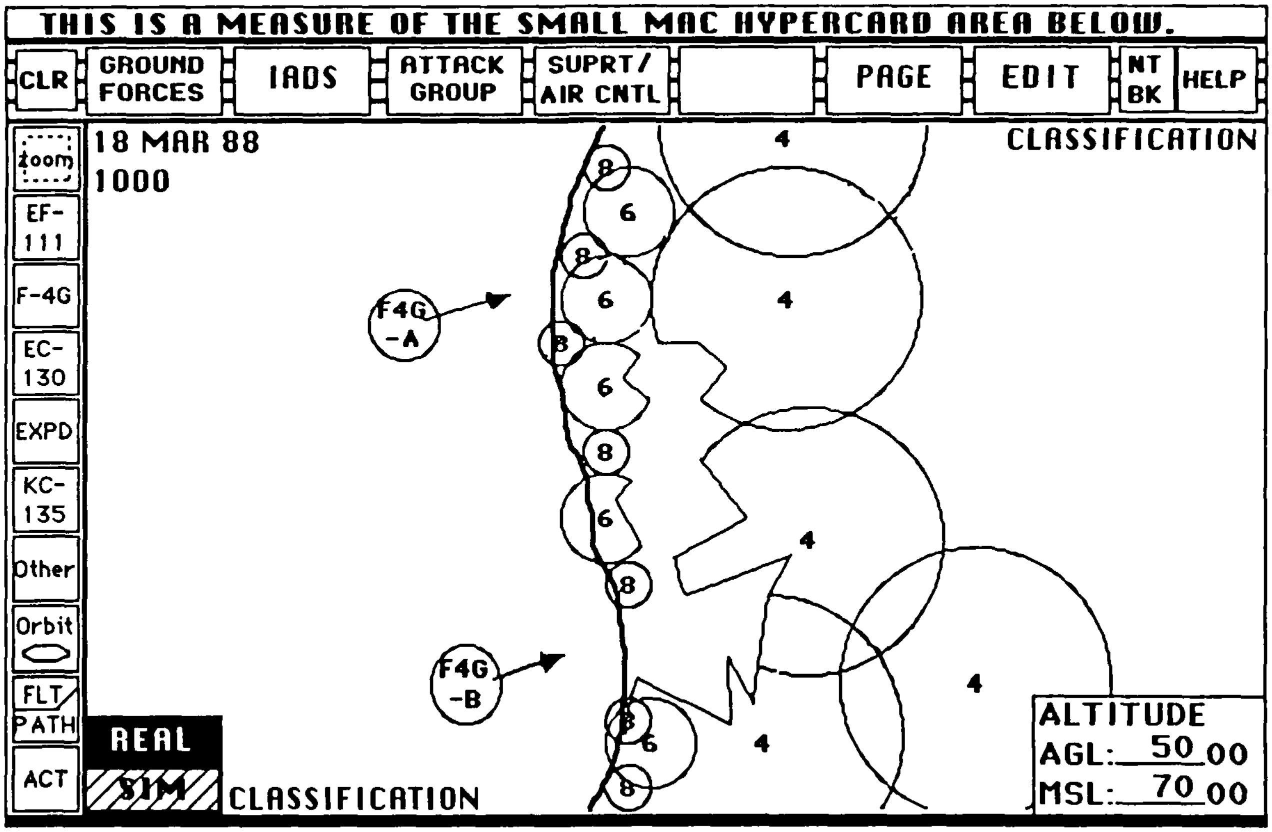
ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT

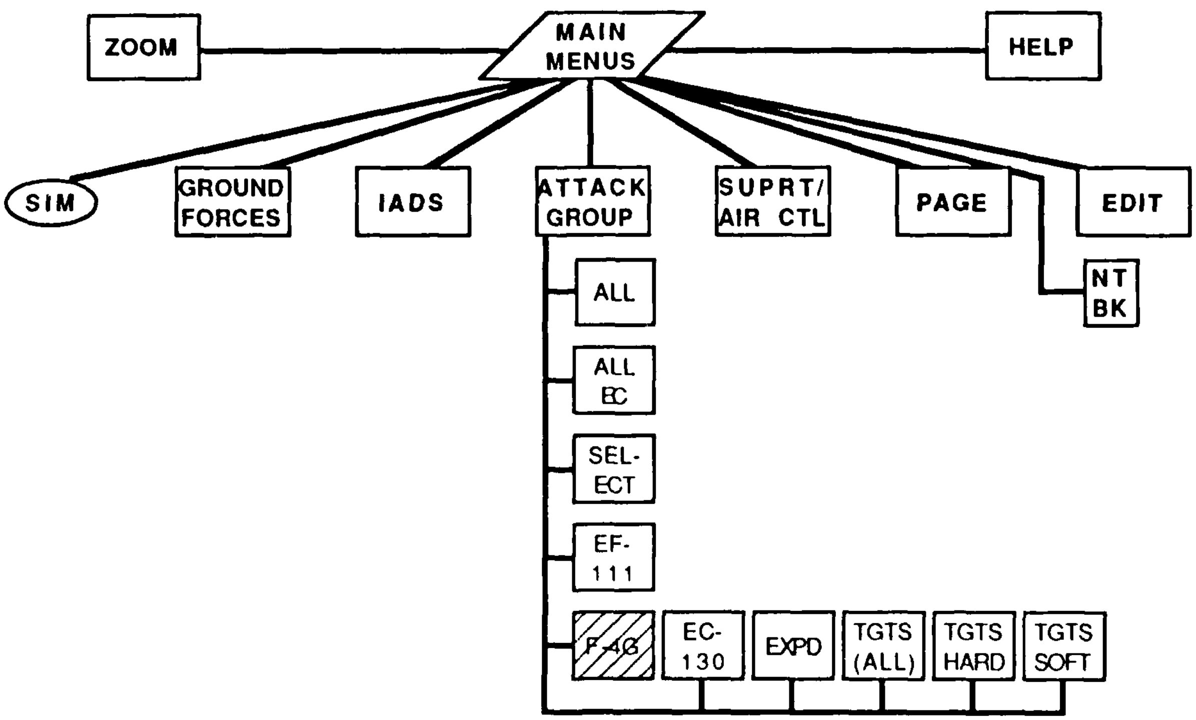

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
88
CLASSIFICATION
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
ATK FORCE A
ATK FORCE B
TR11288 -ATK A
F4G EDGER 45
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

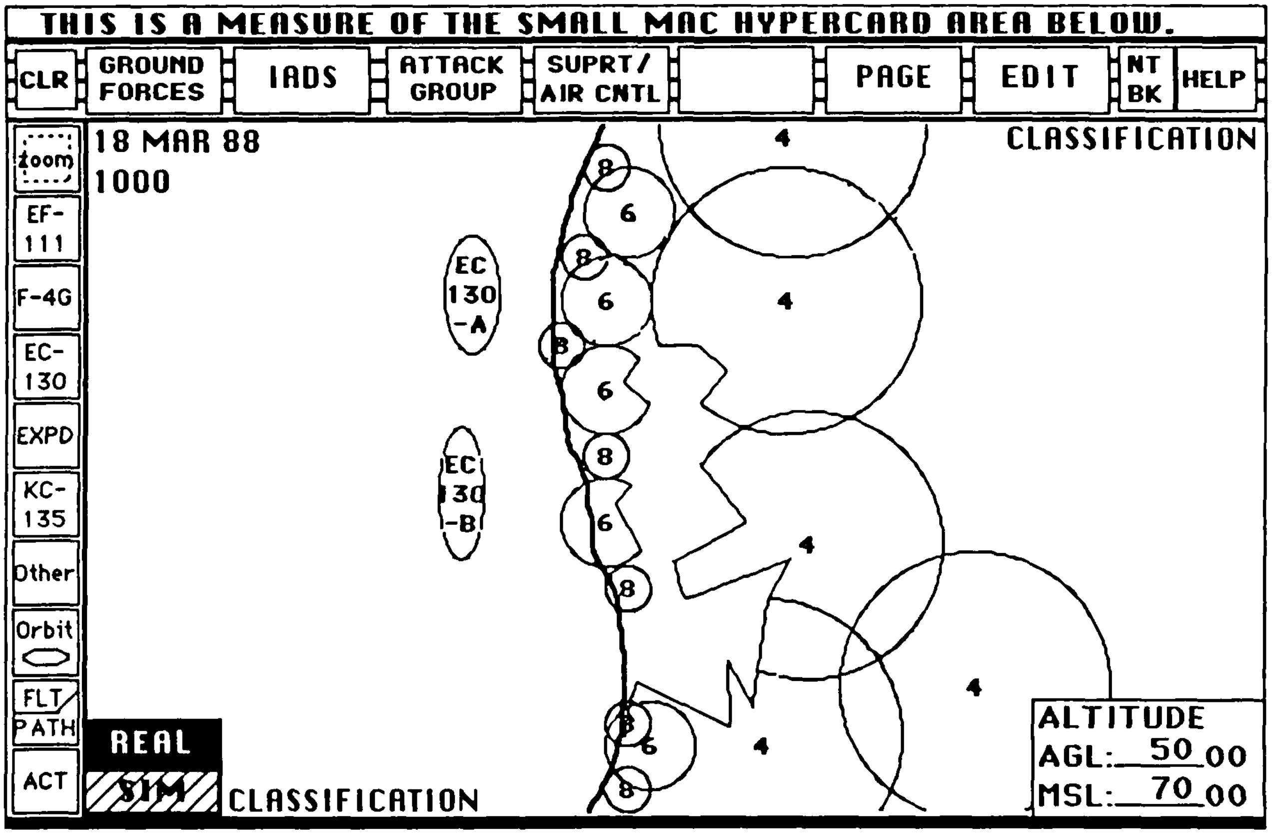

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT

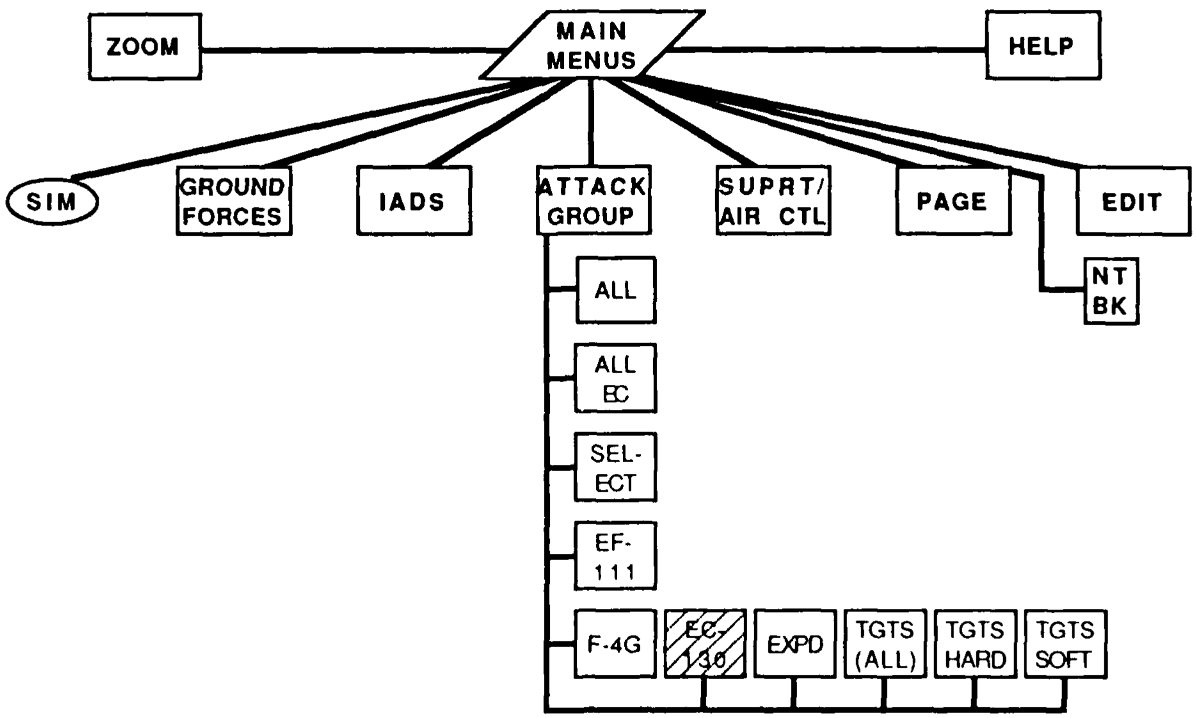

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
EF 111 -A
EF 111 -B
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

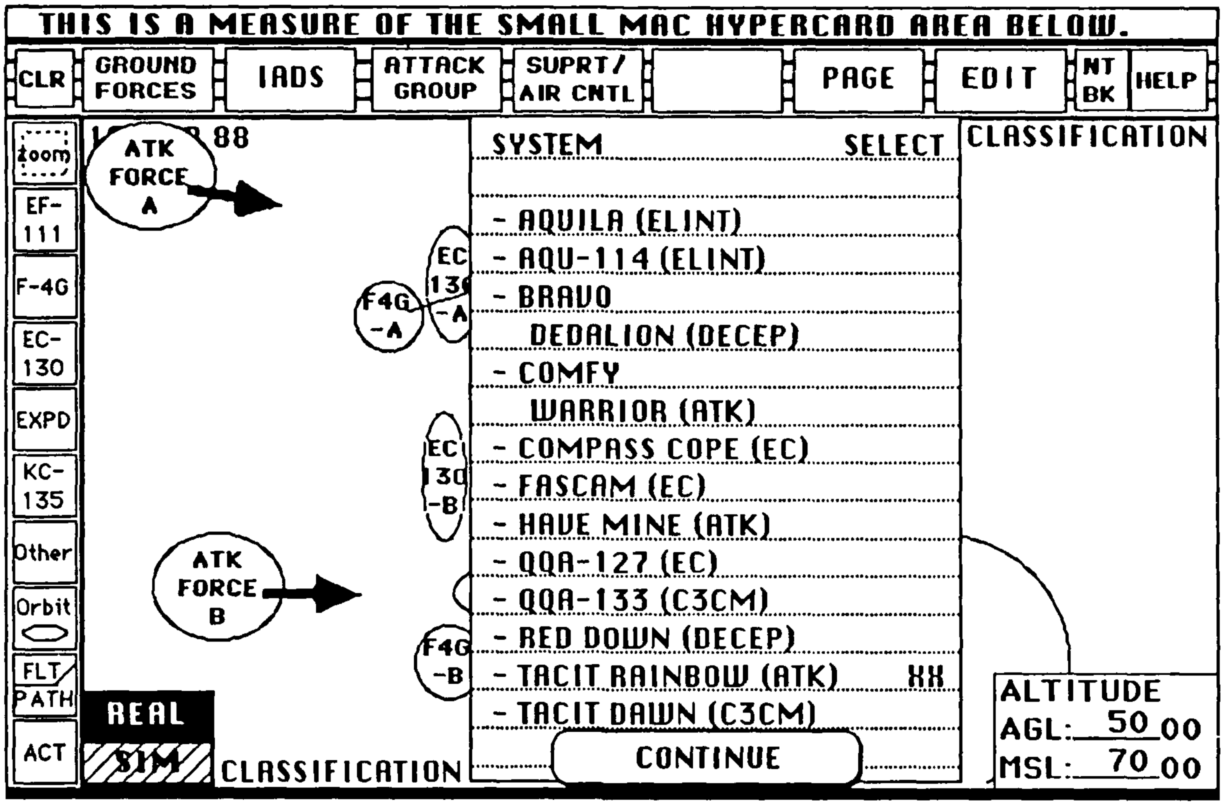

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT

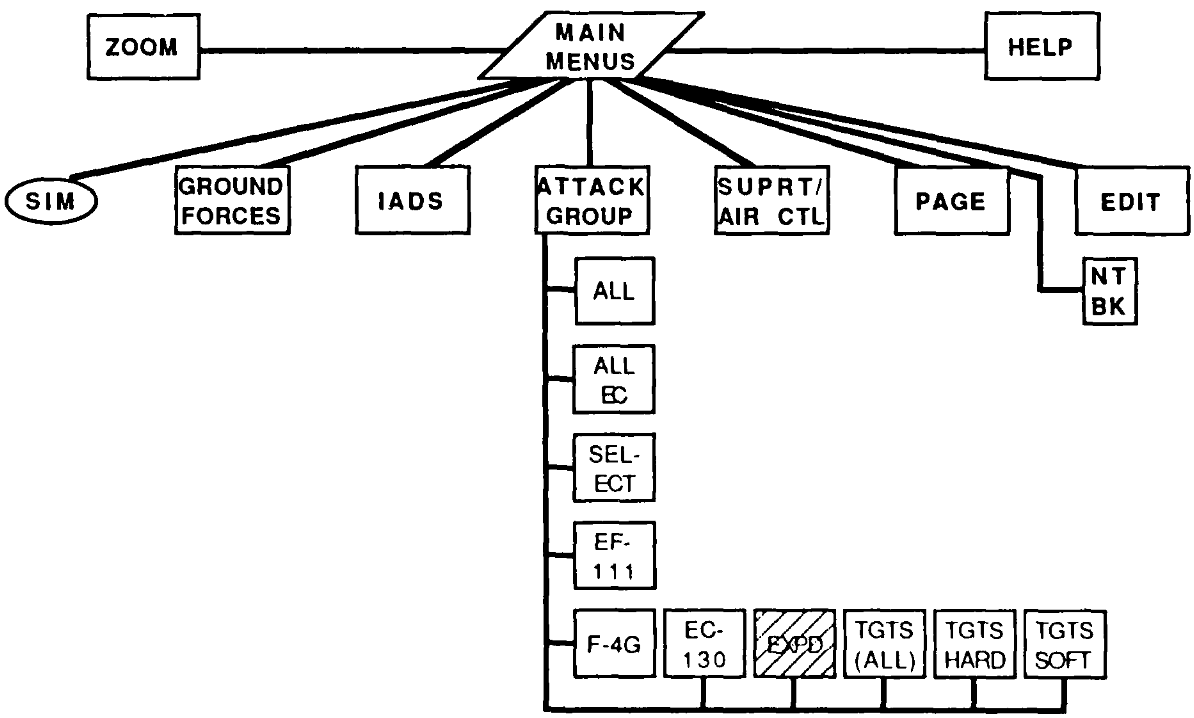

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
F4G -A
F4G -B
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

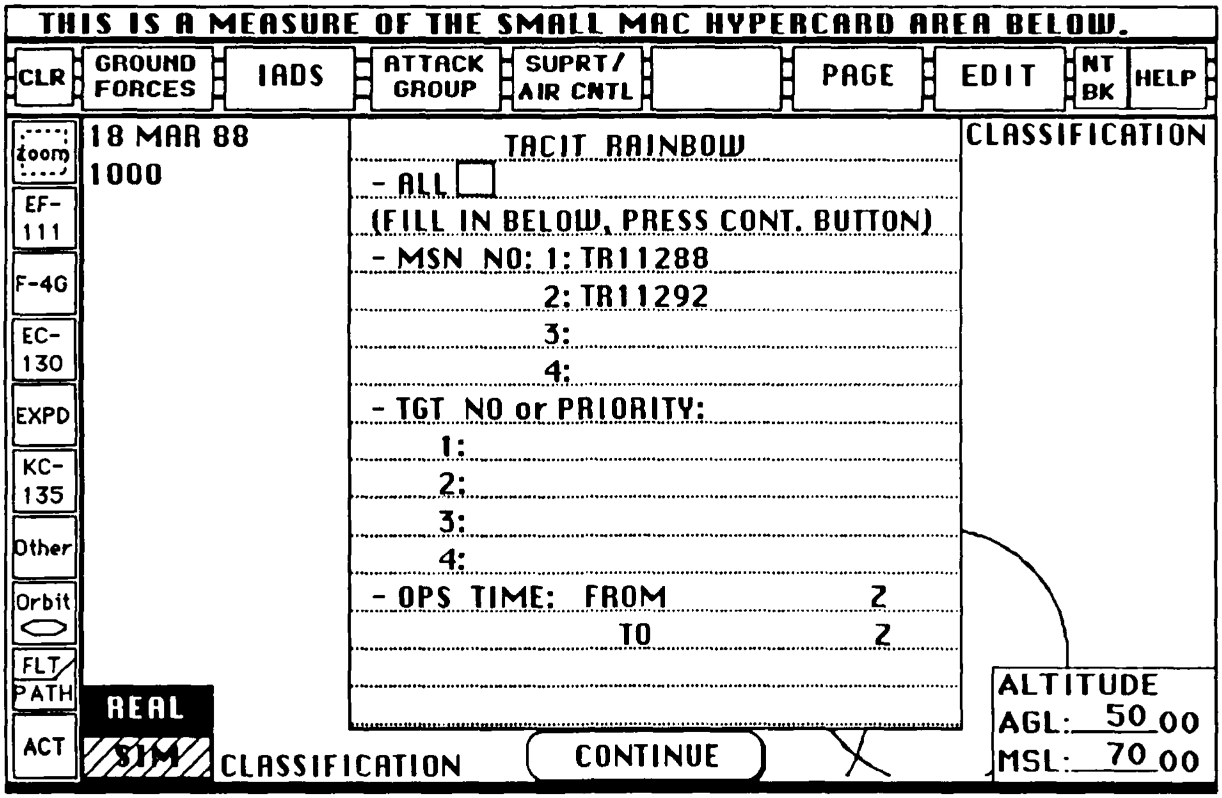

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
Zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
EC 130 -A
EC 130 -B
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

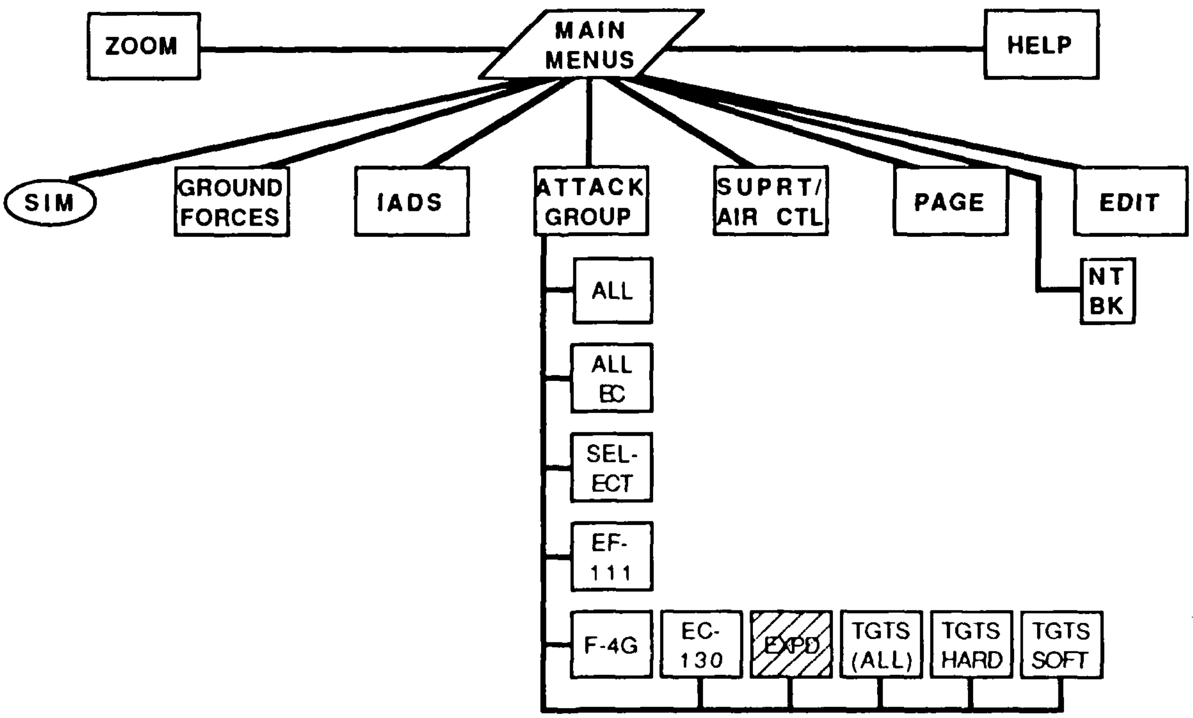

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
ATK FORCE A
ATK FORCE B
REAL
SIM
CLASSIFICATION
SYSTEM
SELECT
- AQUILA (ELINT)
- AQU-114 (ELINT)
- BRAVO DEDALION (DECEP)
- COMFY WARRIOR (ATK)
- COMPASS COPE (EC)
- FASCAM (EC)
- HAVE MINE (ATK)
- QQA-127 (EC)
- QQA-133 (C3CM)
- RED DOWN (DECEP)
- TACIT RAINBOW (ATK) XX
- TACIT DAWN (C3CM)
CONTINUE
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

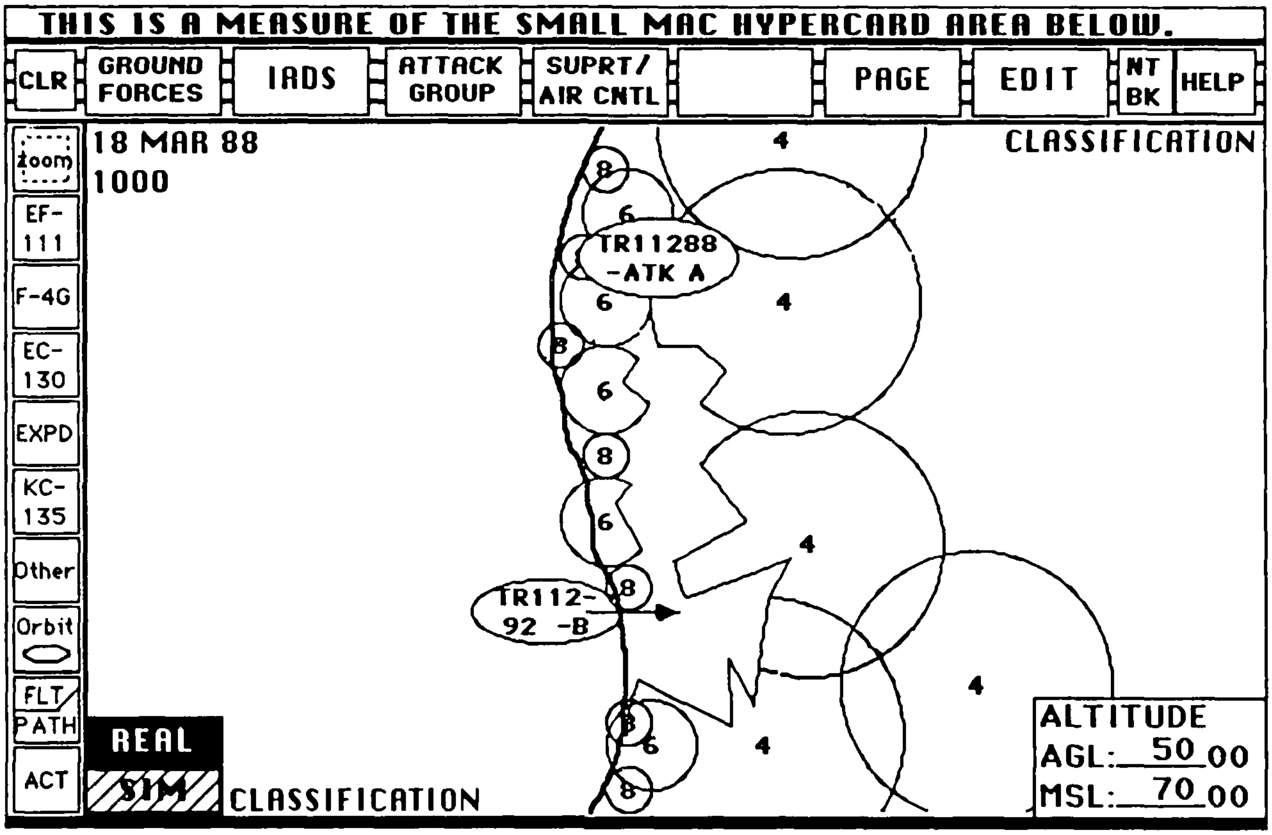

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT

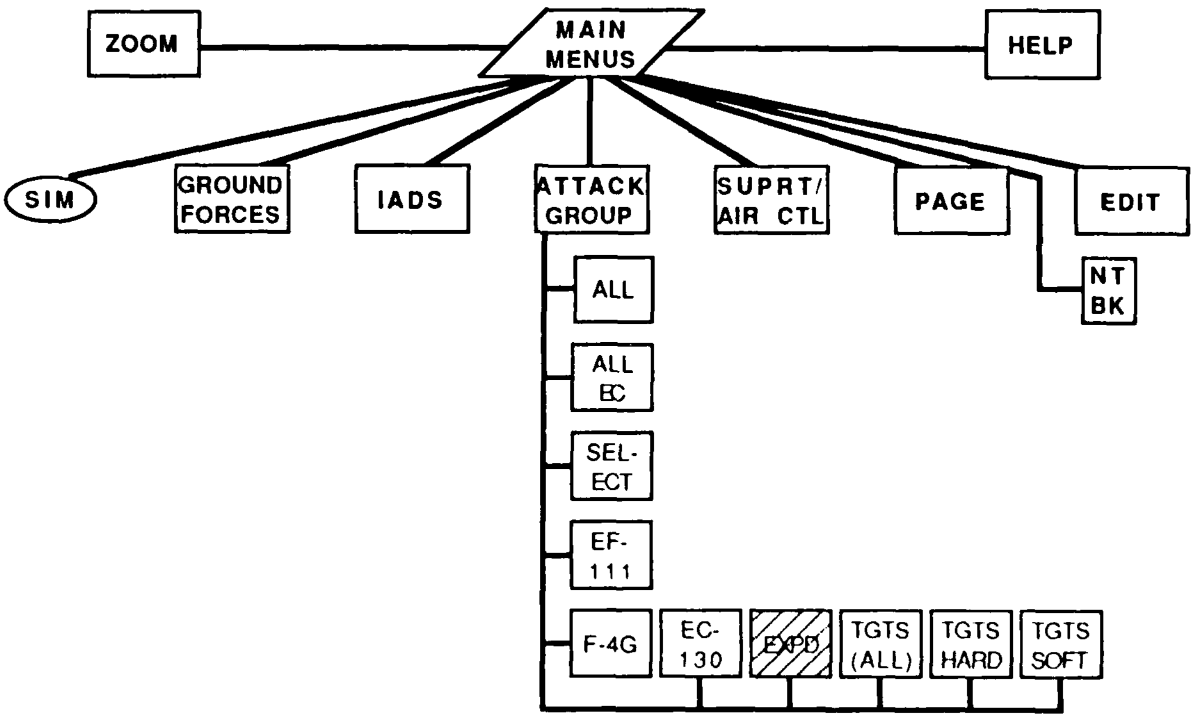


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
Zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
REAL
SIM
CLASSIFICATION
TACIT RAINBOW
- ALL
(FILL IN BELOW, PRESS CONT. BUTTON)
- MSN NO: 1: TR11288
2: TR11292
3:
4:
- TGT NO or PRIORITY:
1:
2:
3:
4:
- OPS TIME: FROM Z
TO Z
CONTINUE
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00



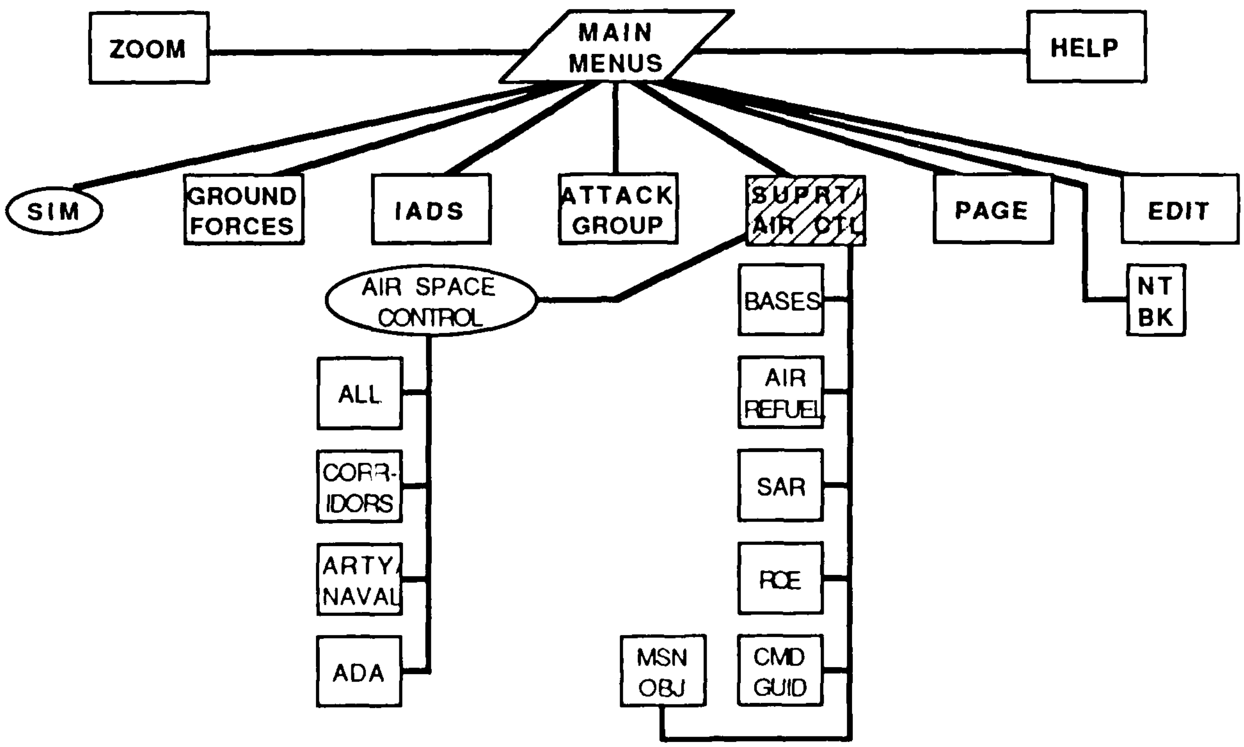
ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT

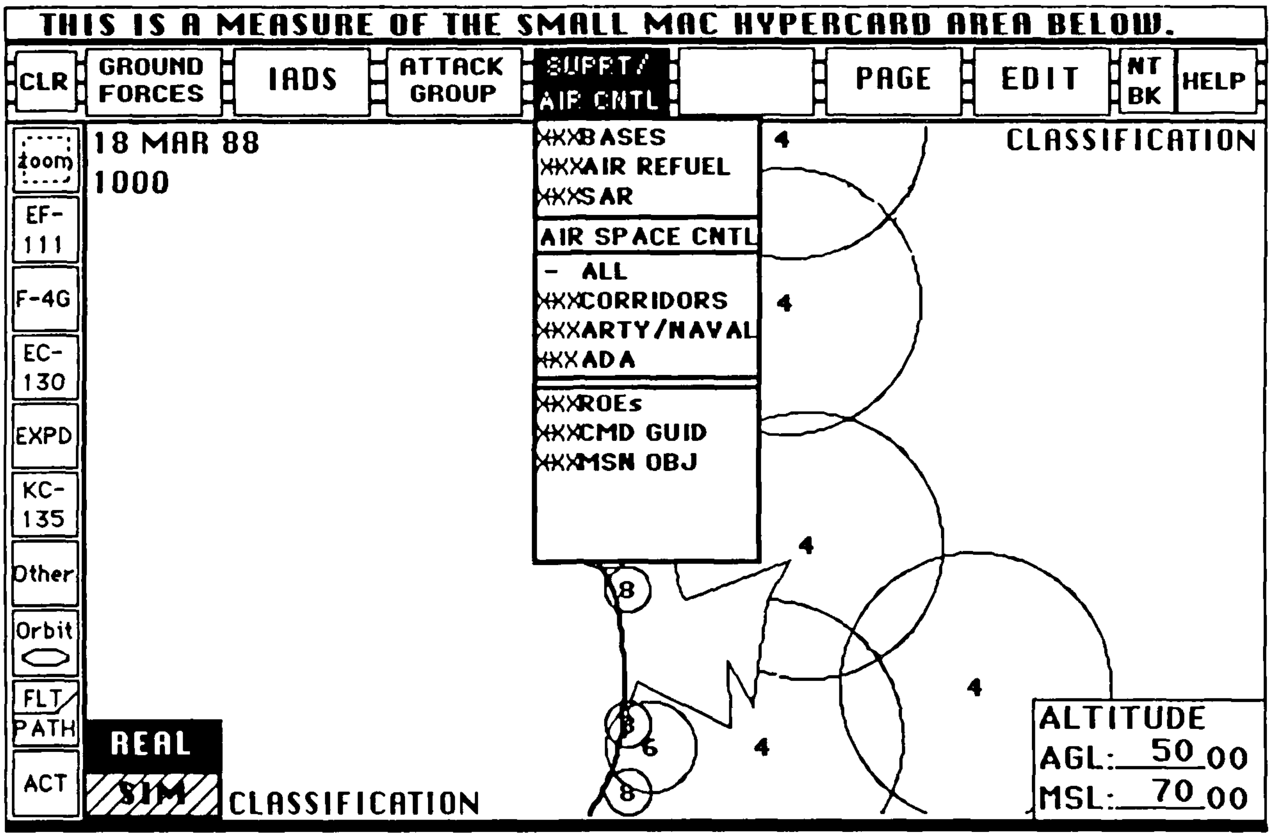

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
TR11288 -ATK A
TR112-92 -B
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

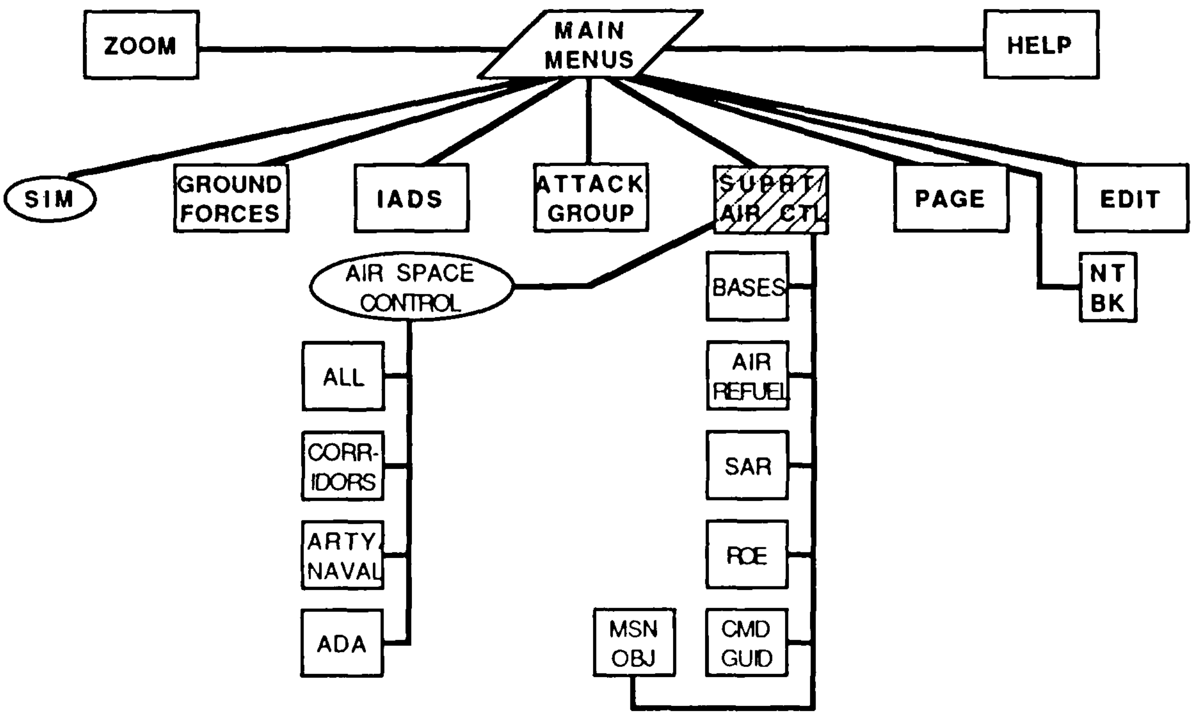

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
ALL
ALL EC
SEL-ECT
EF-111
F-4G
EC-130
EXPD
TGTS (ALL)
TGTS HARD
TGTS SOFT

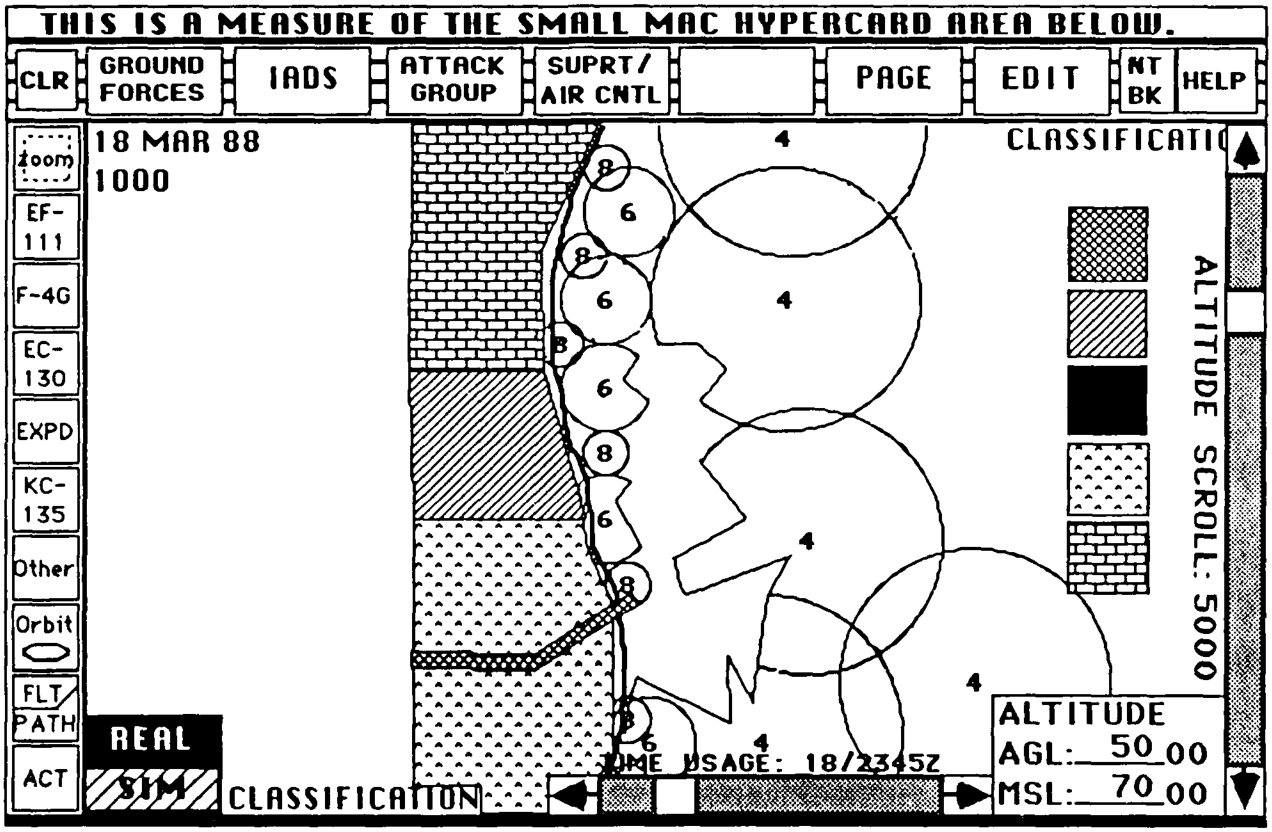
Support / Air Control

The SUPPORT / AIR CONTROL menu control enables the user to access information on the various mechanisms required to support air operations, such as bases, to access mission guidance information, such as ROEs (rules of engagement), and to access information on air space control issues. The user is able to access information for air space control issues over both varying altitude and time. See the HELP file for a thorough explanation of the representations, operations, memory aids, and control mechanism available to the user on these pages.

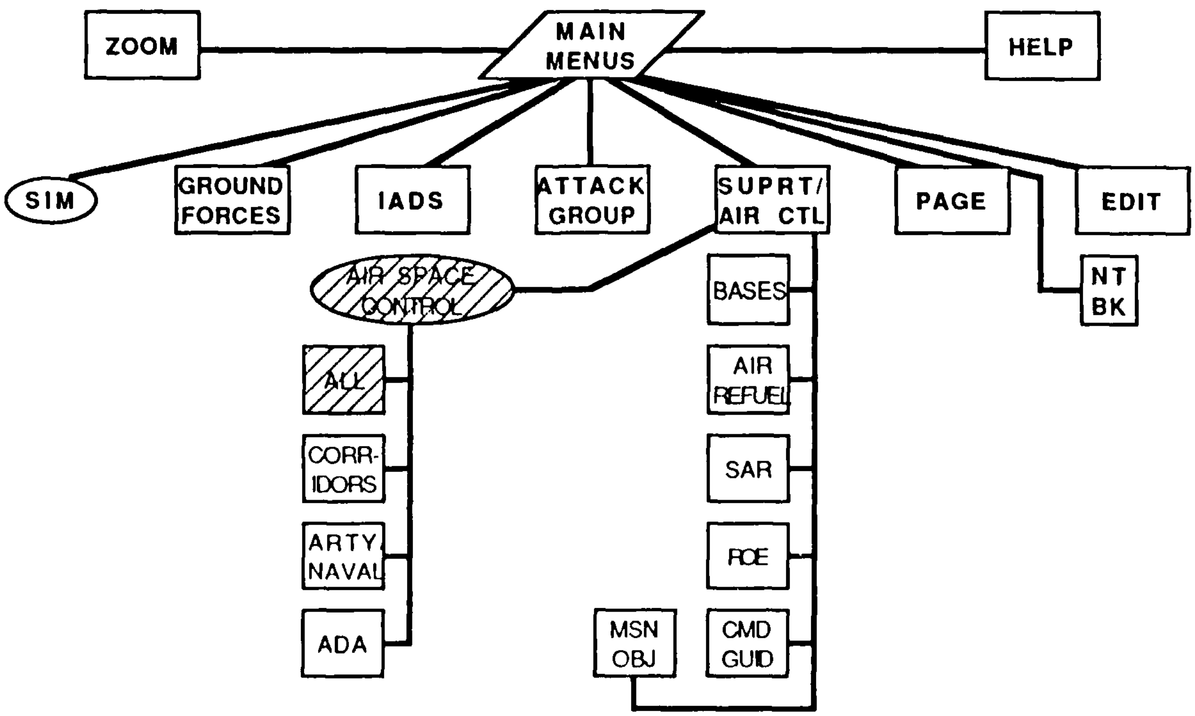



THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPPT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
Zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
XXXBASES
XXXAIR REFUEL
XXXSAR
AIR SPACE CNTL
- ALL
XXXCORRIDORS
XXXARTY/NAVAL
XXXADA
XXXROEs
XXXCMD GUID
XXXMSN OBJ
CLASSIFICATION
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00


ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPPT/ AIR CTL
PAGE
EDIT
NT BK
AIR SPACE CONTROL
ALL
CORR-IDORS
ARTY NAVAL
ADA
BASES
AIR REFUEL
SAR
ROE
CMD GUID
MSN OBJ



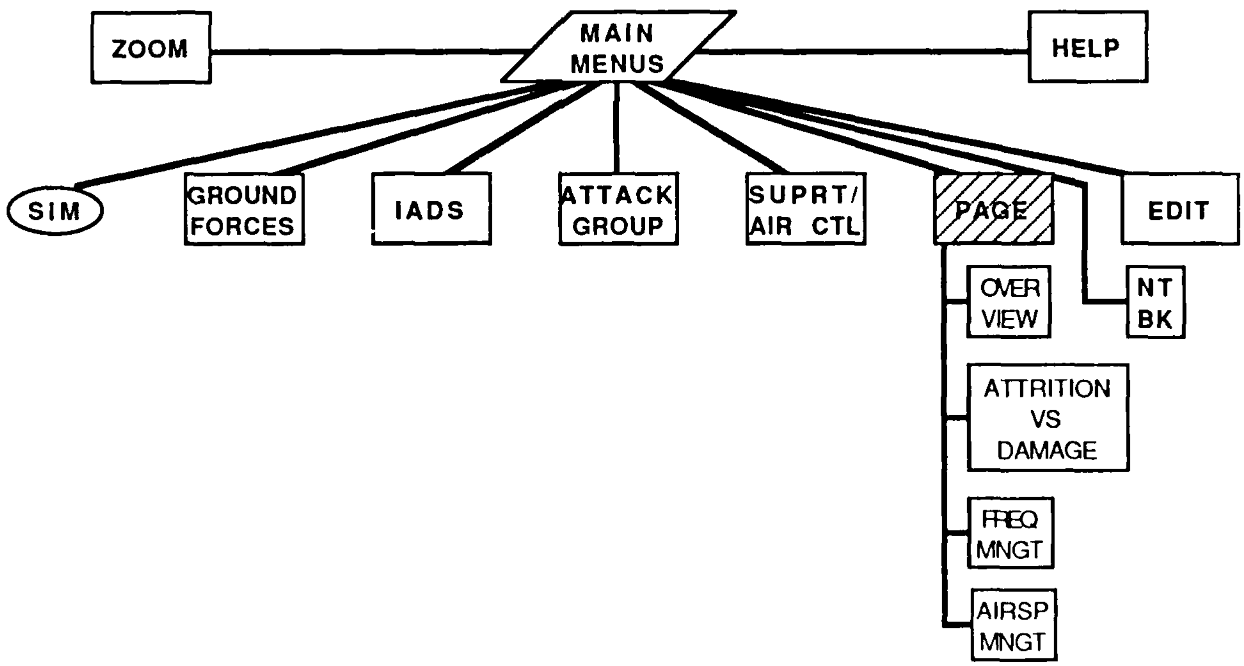
THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
Zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
REAL
SIM
CLASSIFICATION
CLASSIFICATI
ALTITUDE SCROLL: 5000
TIME USAGE: 18/2345Z
ALTITUDE
AGL: 50 00
MSL: 70 00

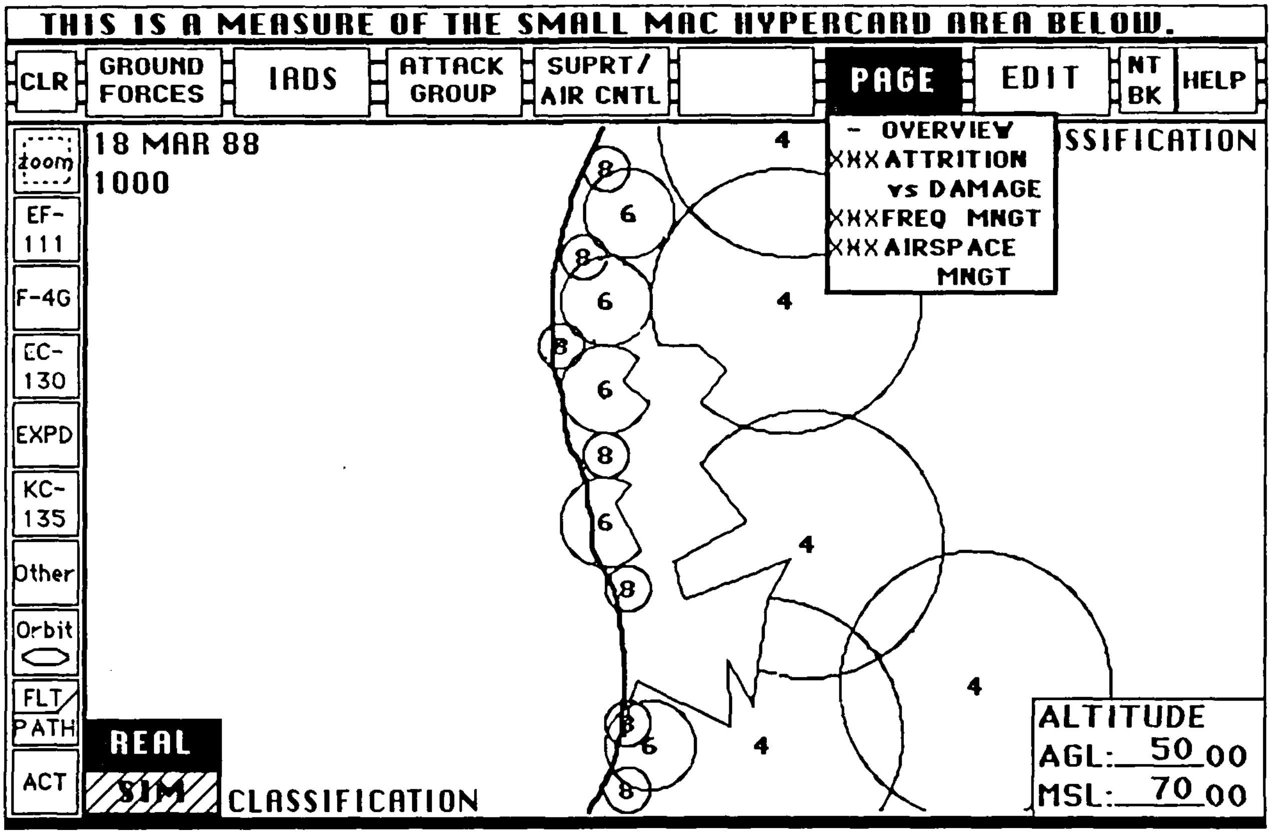


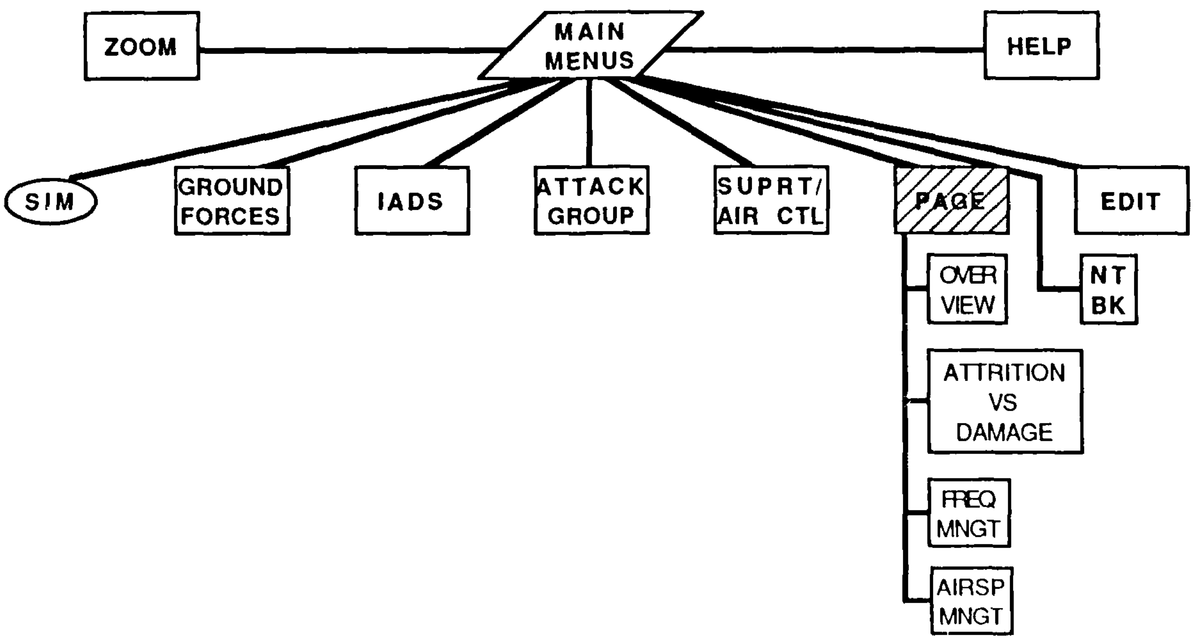
ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
AIR SPACE CONTROL
ALL
CORR-IDORS
ARTY NAVAL
ADA
BASES
AIR REFUEL
SAR
ROE
CMD GUID
MSN OBJ

Page

The PAGE menu control enables the user to move to other page formats which are basically different so as to support other aspects of the planning-evaluation-decision steps. These other pages support attrition-damage analysis, frequency management, and air space management. The capability to directly support the generation of new displays, a DESIGN page, to indicated user desired changes and enhancements is to be added later. See the HELP file for a thorough explanation of the representations, operations, memory aids, and control mechanism available to the user on these pages.

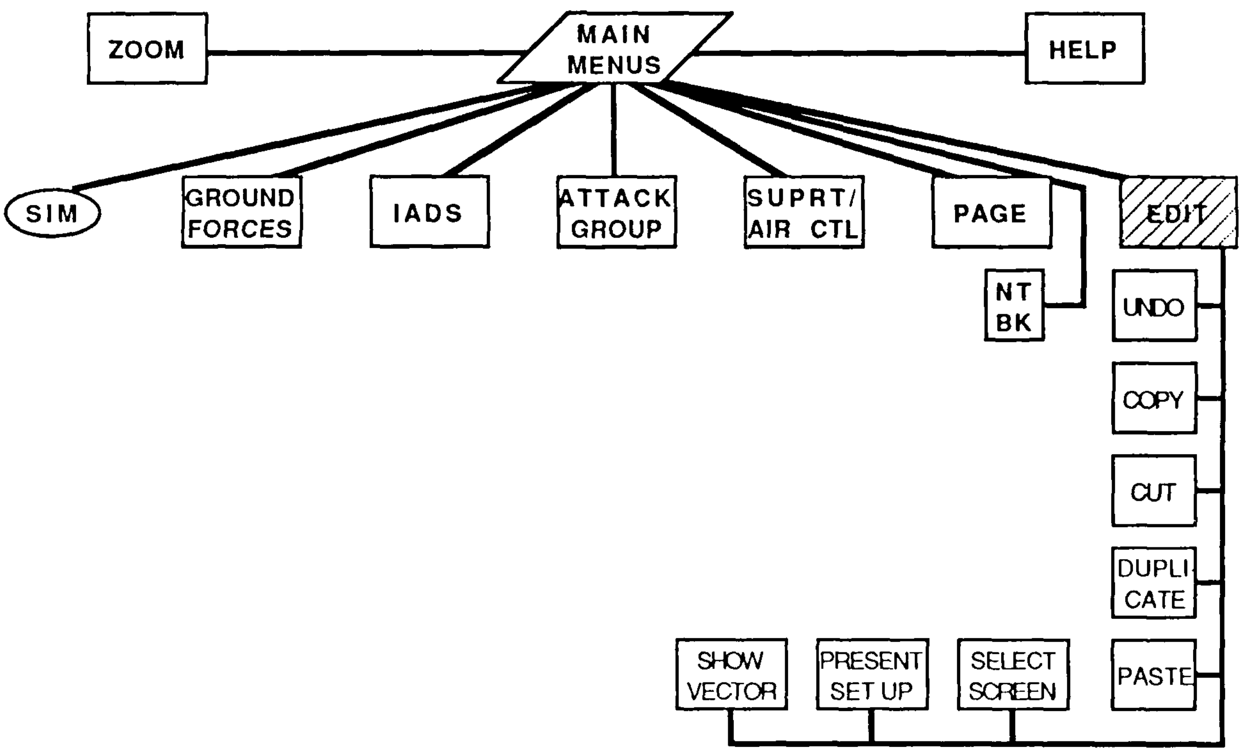


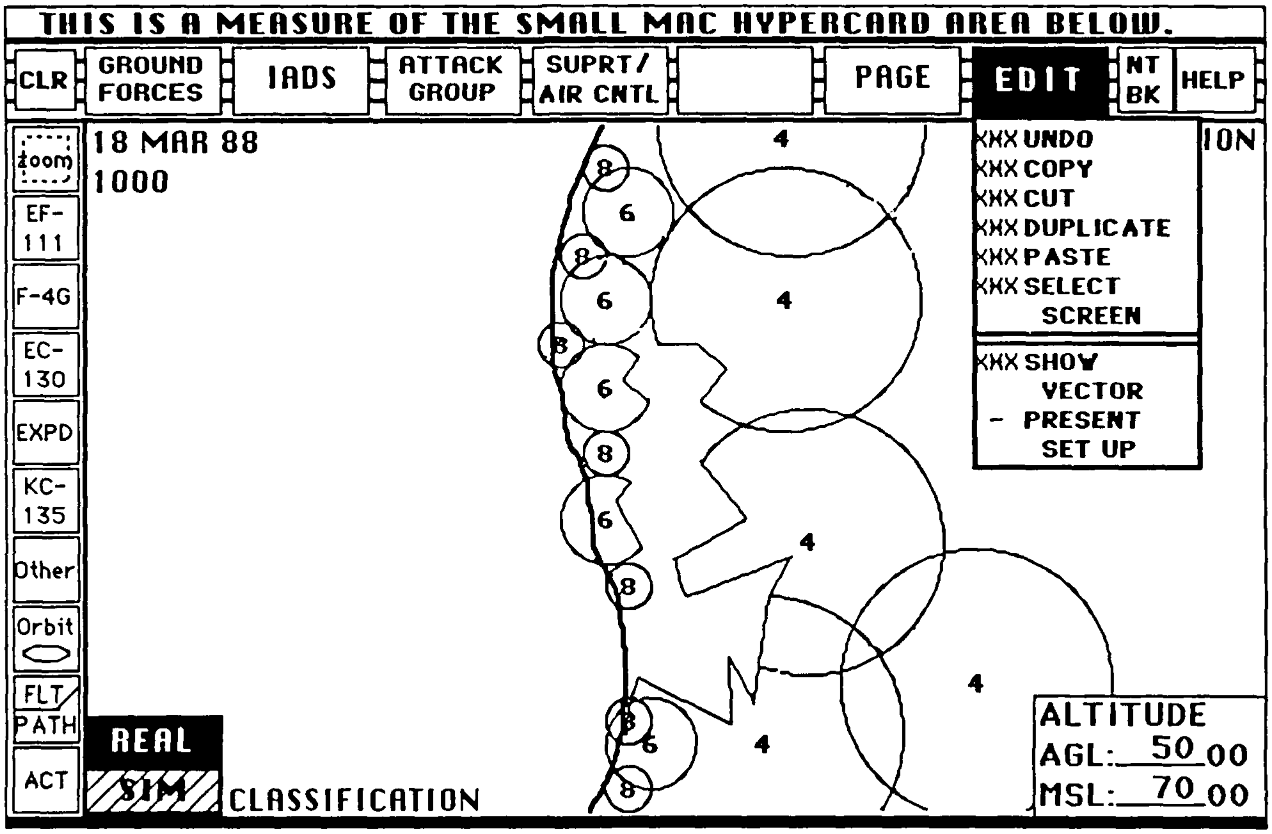

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
- OVERVIEW
XXX ATTRITION vs DAMAGE
XXX FREQ MNGT
XXX AIRSPACE MNGT
SSIFICATION
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

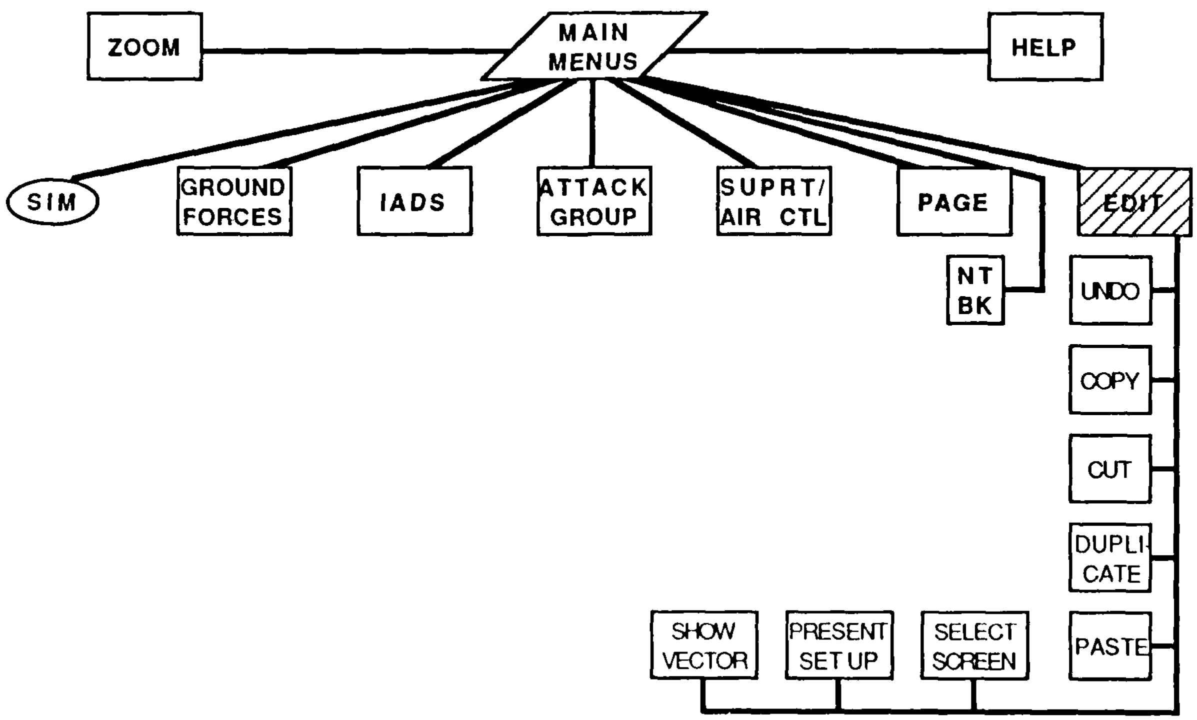

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
OVER VIEW
NT BK
ATTRITION VS DAMAGE
FREQ MNGT
AIRSP MNGT

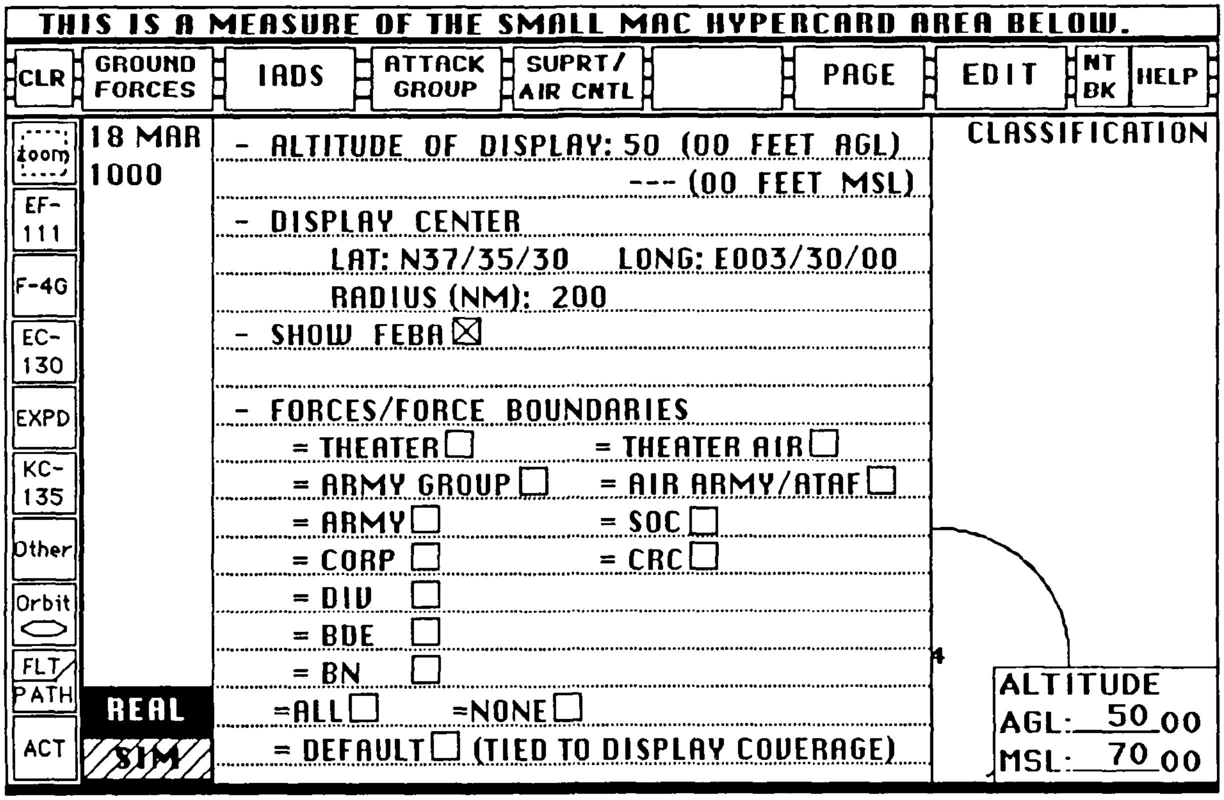
Edit

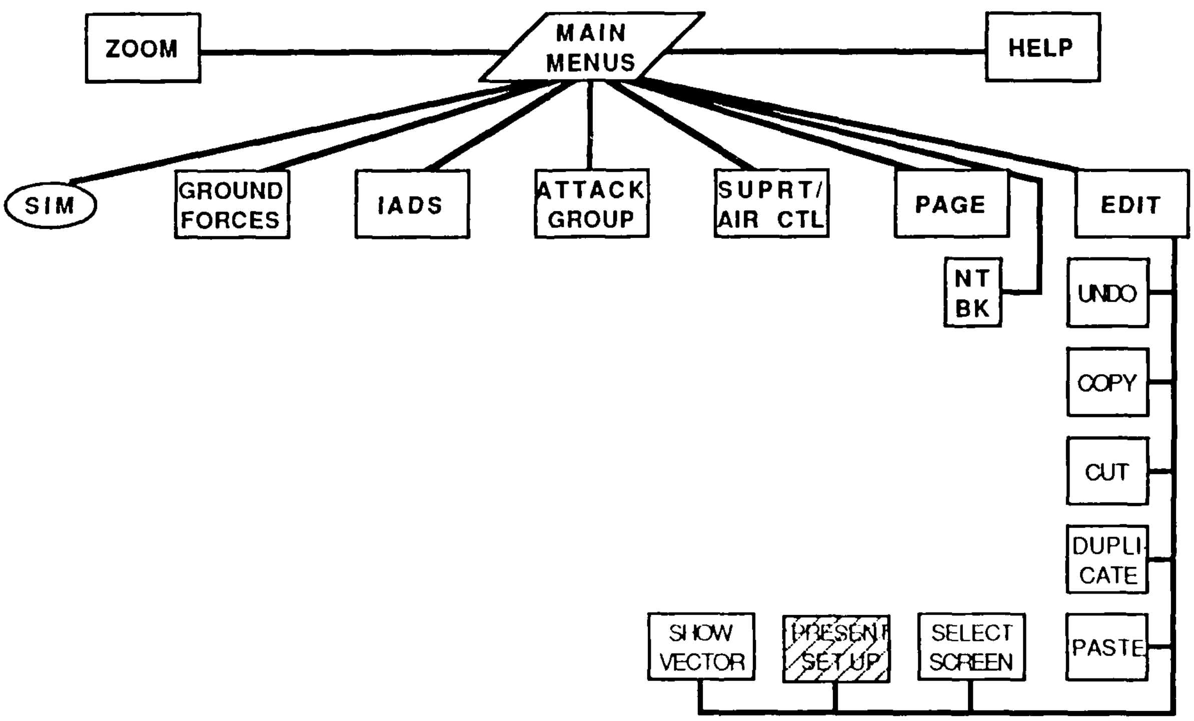
The EDIT menu control enables the selection of display information and the user's ability to construct, manipulate, and terminate simulations. See the HELP file for a thorough explanation of the representations, operations, memory aids, and control mechanism available to the user on these pages.




THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
XXX UNDO
XXX COPY
XXX CUT
XXX DUPLICATE
XXX PASTE
XXX SELECT SCREEN
XXX SHOW VECTOR
- PRESENT SET UP
ION
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

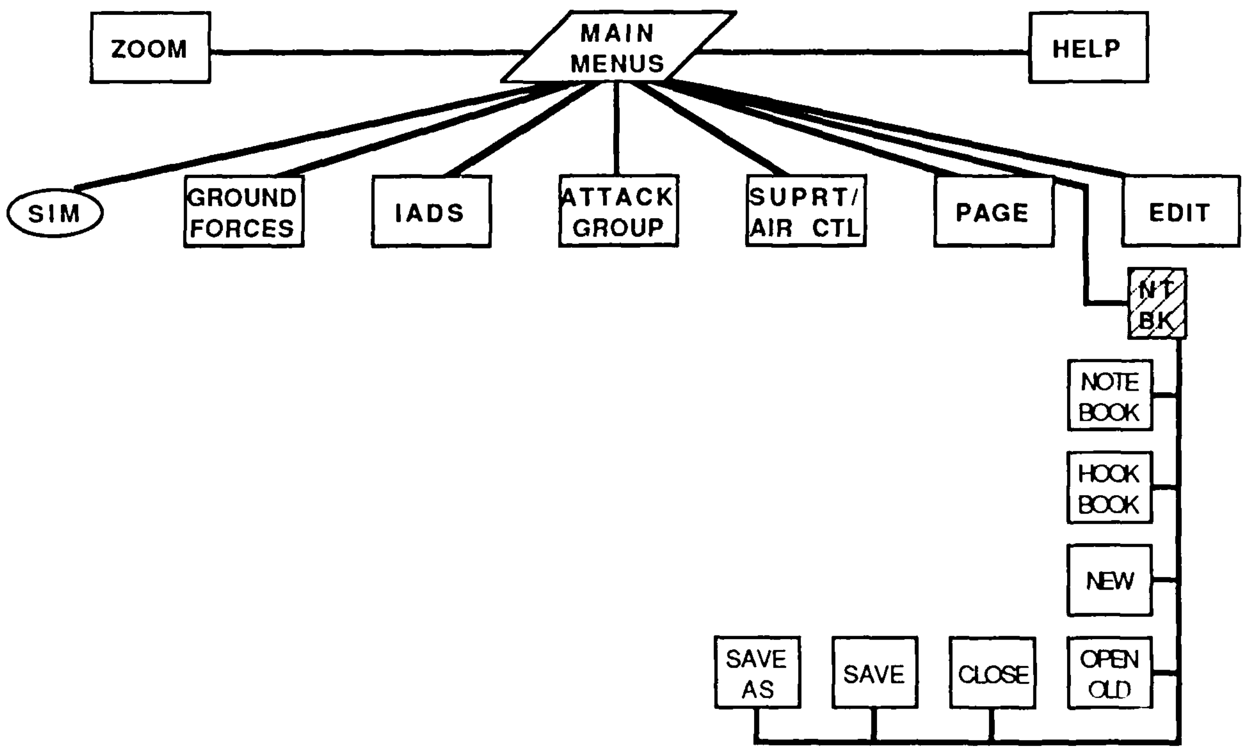

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
UNDO
COPY
CUT
DUPLICATE
PASTE
SHOW VECTOR
PRESENT SET UP
SELECT SCREEN

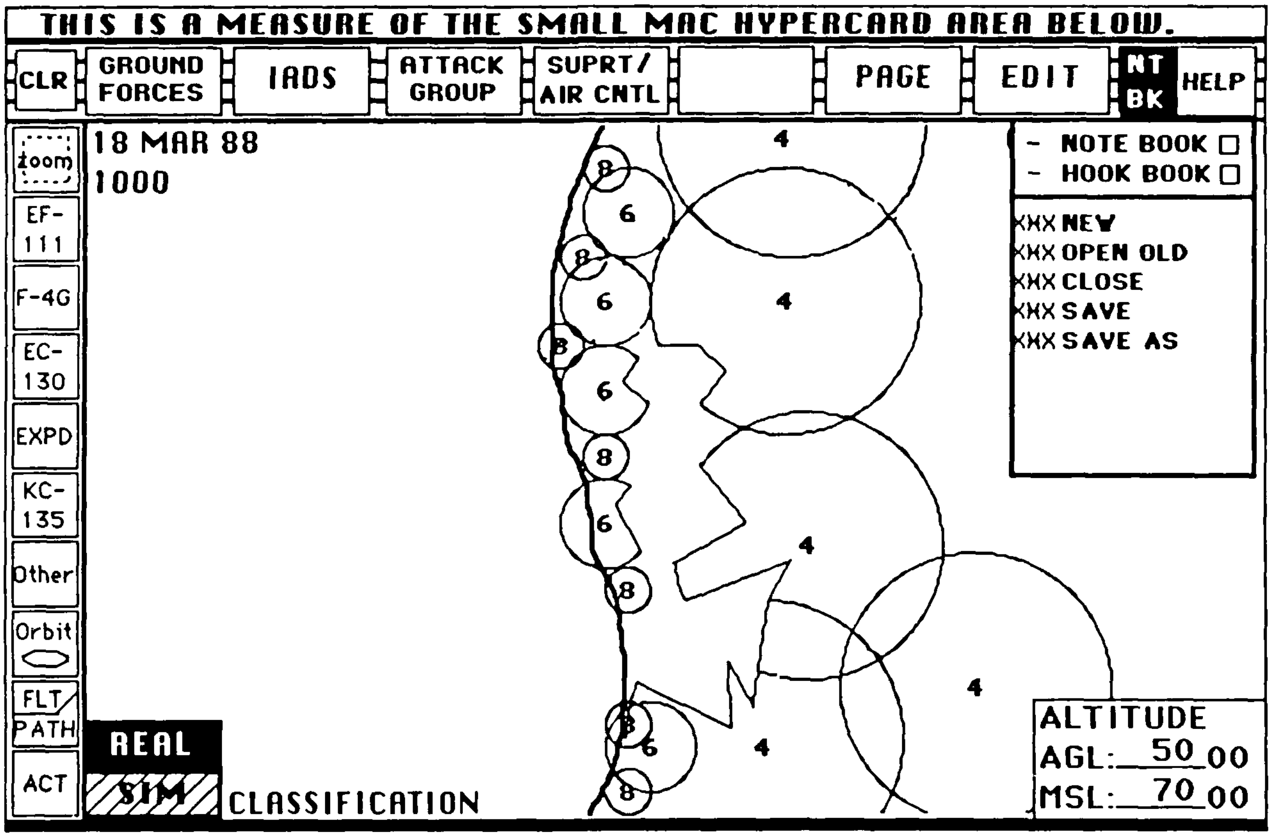

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR
1000
REAL
SIM
- ALTITUDE OF DISPLAY: 50 (00 FEET AGL)
--- (00 FEET MSL)
- DISPLAY CENTER
LAT: N37/35/30 LONG: E003/30/00
RADIUS (NM): 200
- SHOW FEBA
- FORCES/FORCE BOUNDARIES
= THEATER
= THEATER AIR
= ARMY GROUP
= AIR ARMY/ATAF
= ARMY
= SOC
= CORP
= CRC
= DIV
= BDE
= BN
=ALL
=NONE
= DEFAULT (TIED TO DISPLAY COVERAGE)
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

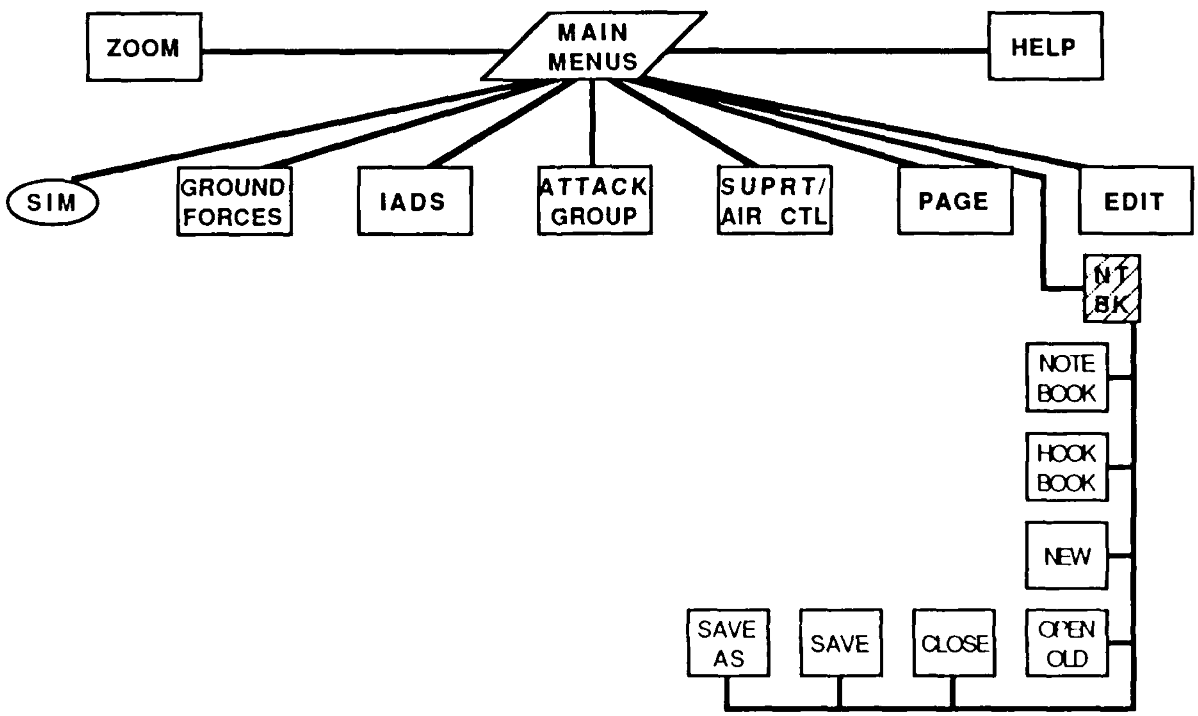

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
UNDO
COPY
CUT
DUPLI- CATE
PASTE
SHOW VECTOR
PRESENT SET UP
SELECT SCREEN

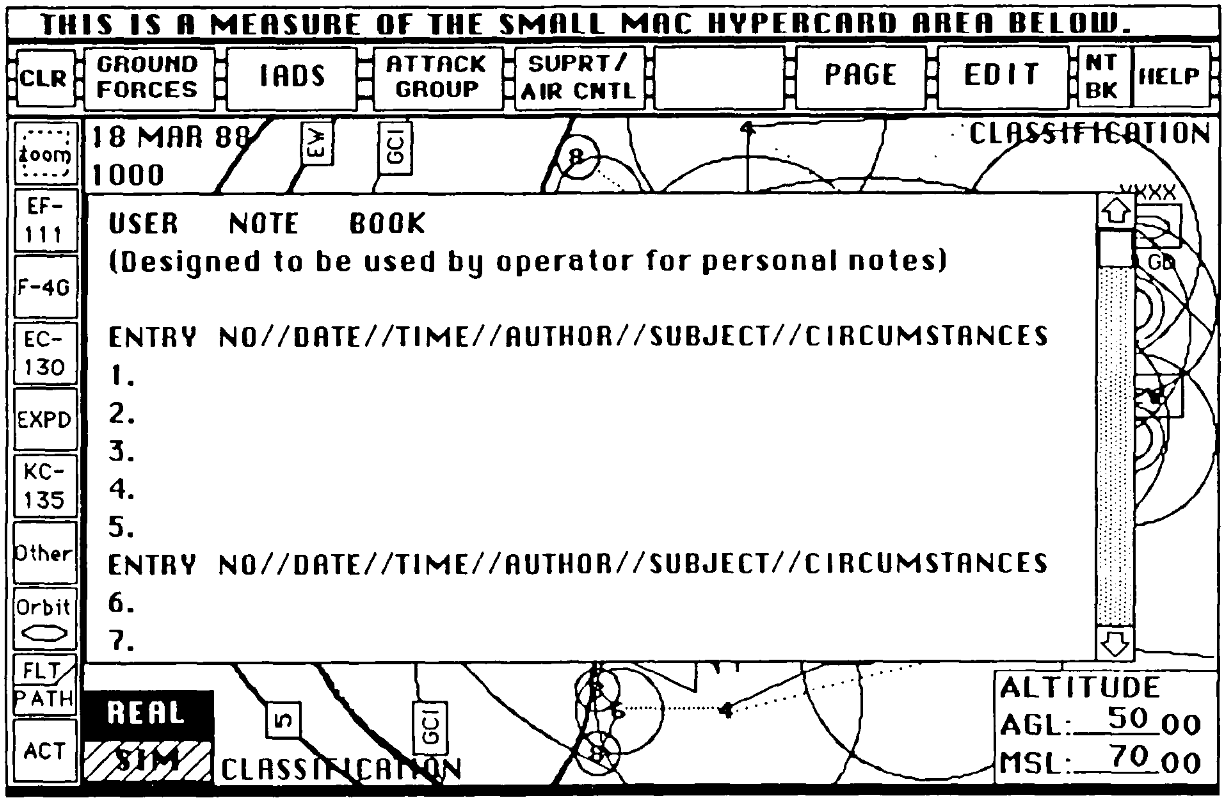
Note Book

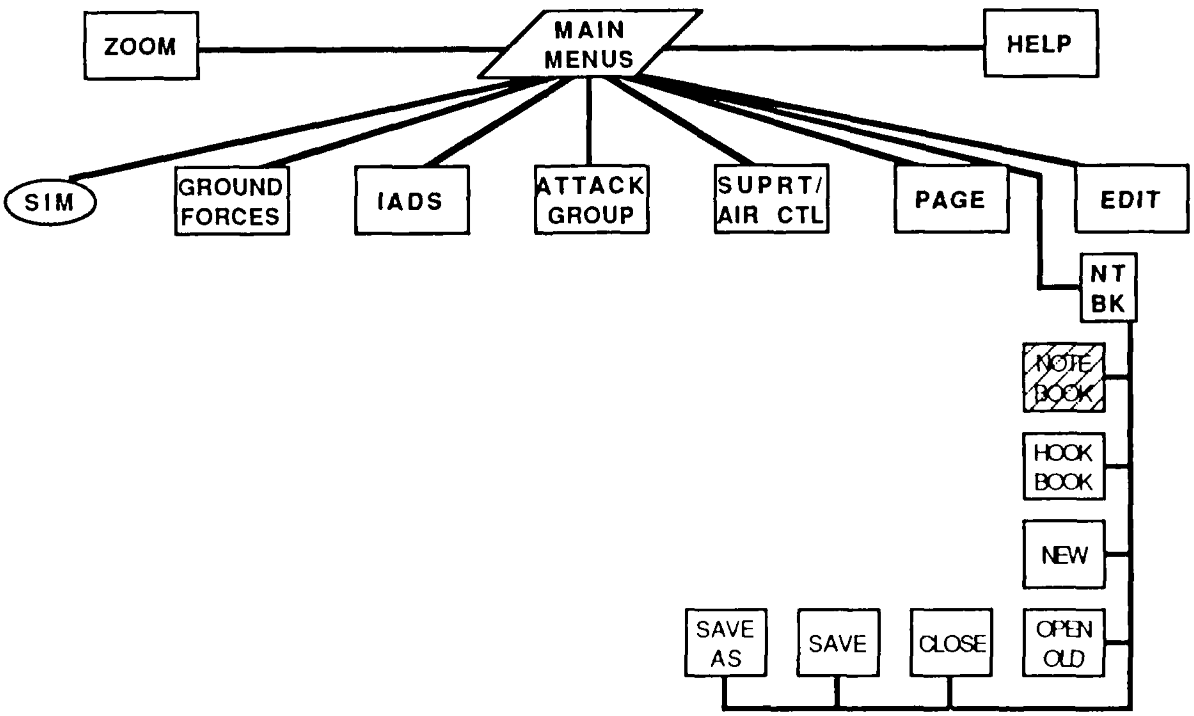
The NOTE BOOK menu control enables the access of either the Note Book or the Hook Book as well as the control of these documents. See the HELP file for a thorough explanation of the representations, operations, memory aids, and control mechanism available to the user on these pages.

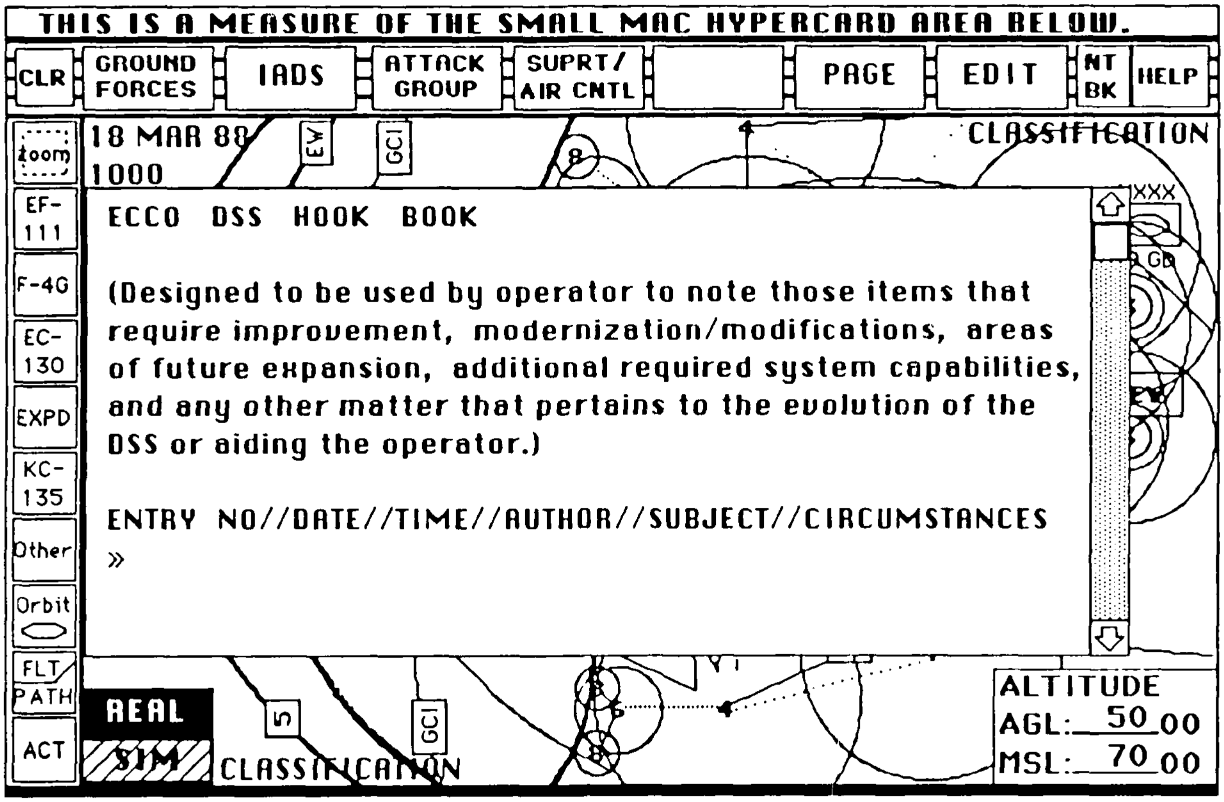


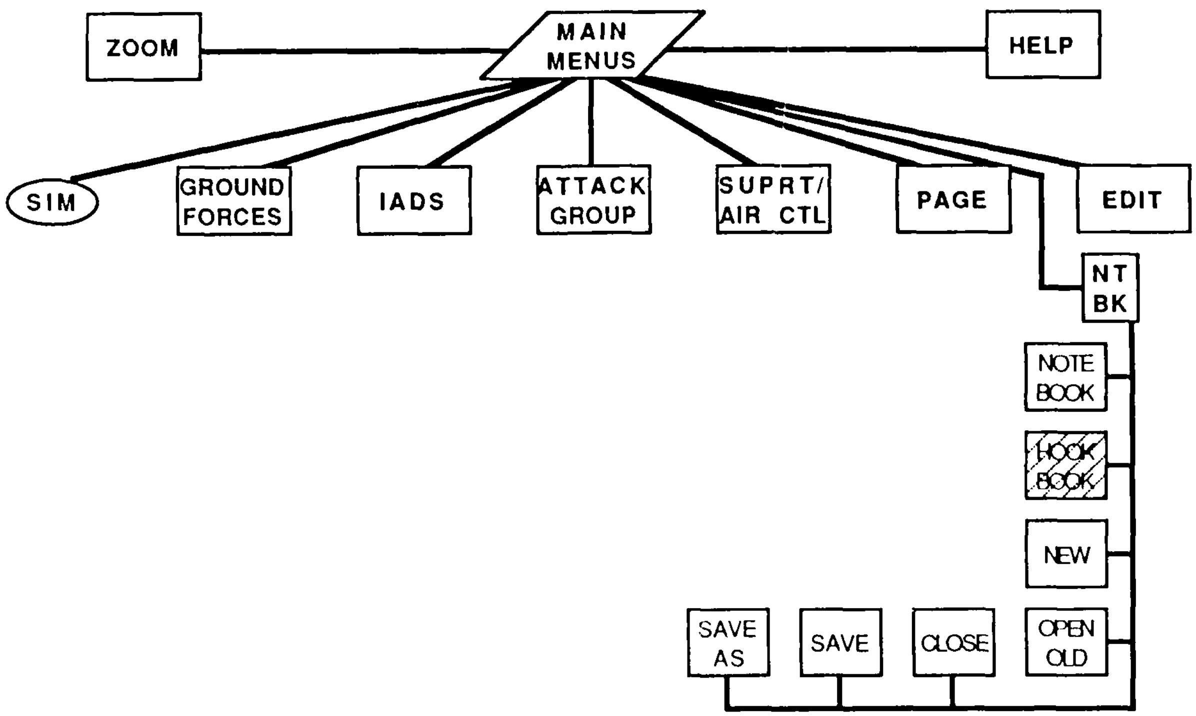

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
REAL
SIM
CLASSIFICATION
- NOTE BOOK
- HOOK BOOK
XXX NEW
XXX OPEN OLD
XXX CLOSE
XXX SAVE
XXX SAVE AS
ALTITUDE
AGL: 50 00
MSL: 70 00


ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
NOTE BOOK
HOOK BOOK
NEW
SAVE AS
SAVE
CLOSE
OPEN OLD


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
18 MAR 88
1000
CLASSIFICATION
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
USER NOTE BOOK
(Designed to be used by operator for personal notes)
ENTRY NO//DATE//TIME//AUTHOR//SUBJECT//CIRCUMSTANCES
1.
2.
3.
4.
5.
ENTRY NO//DATE//TIME//AUTHOR//SUBJECT//CIRCUMSTANCES
6.
7.
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

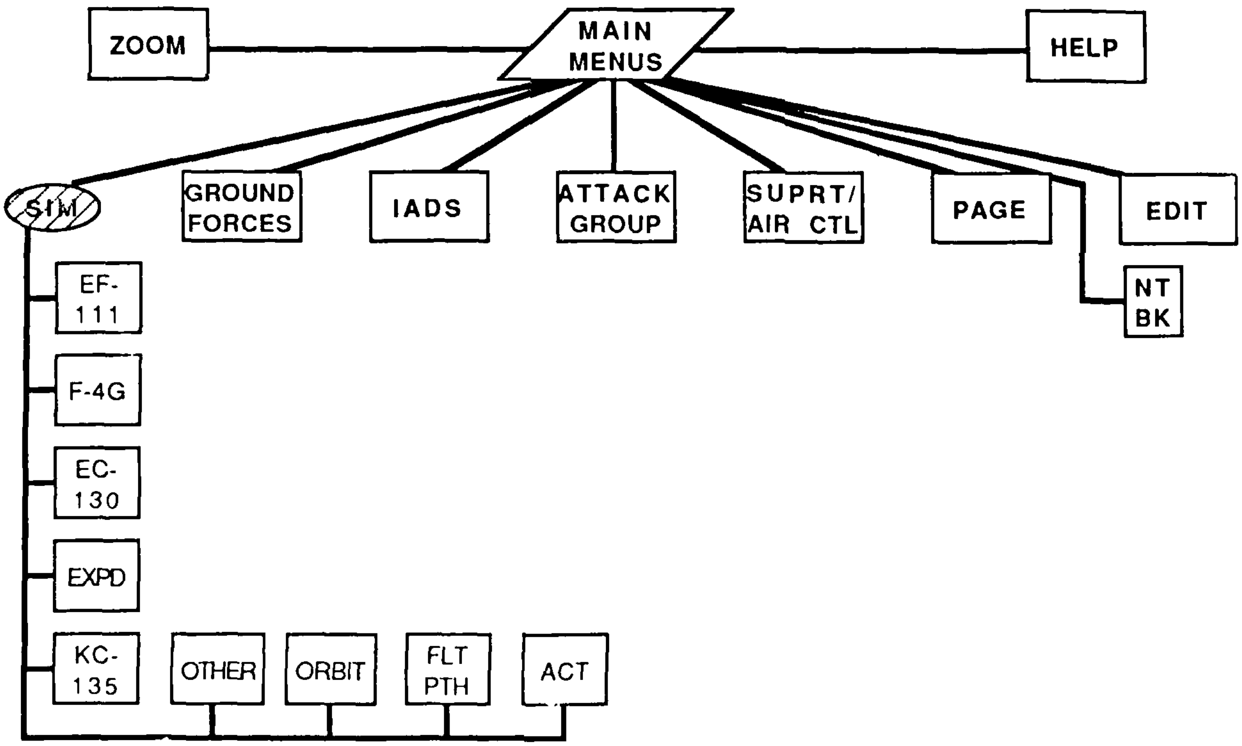

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
NOTE BOOK
HOOK BOOK
NEW
SAVE AS
SAVE
CLOSE
OPEN OLD

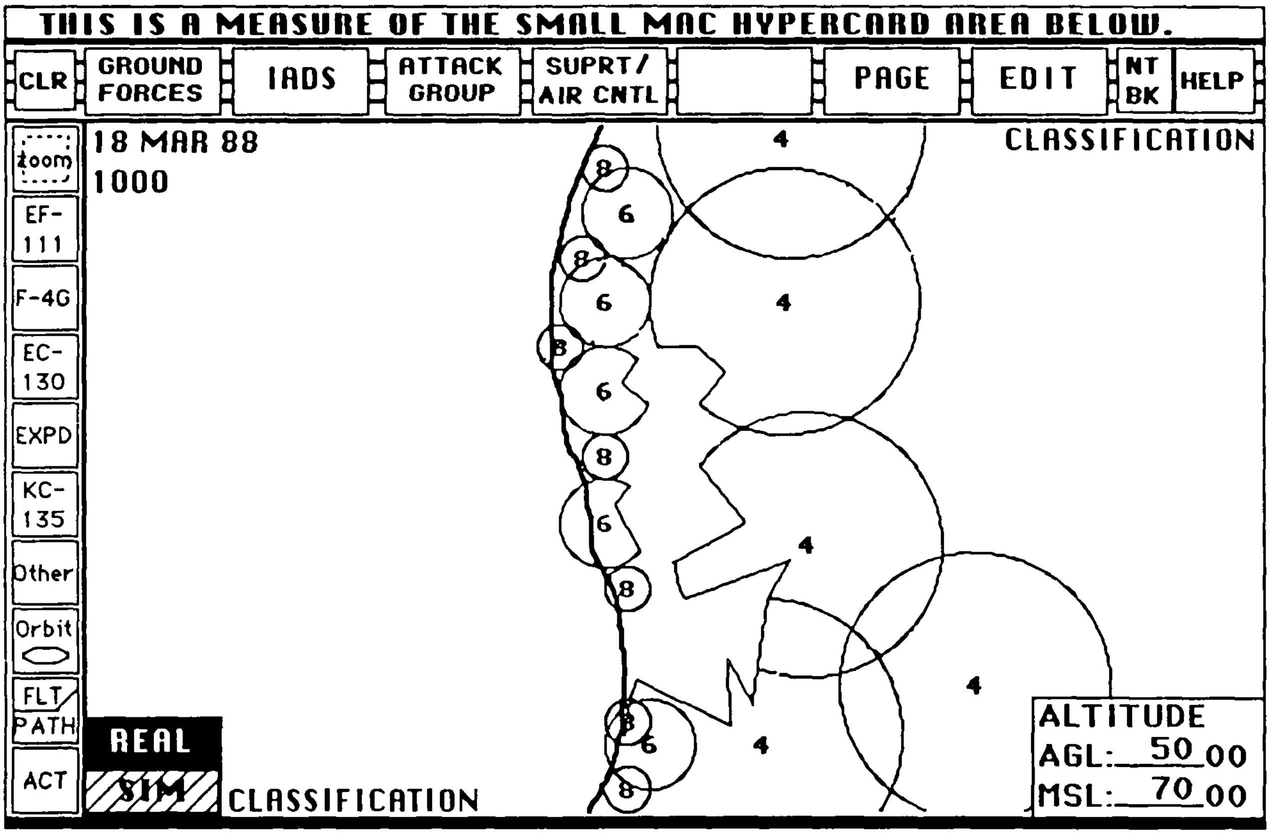

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
ECCO DSS HOOK BOOK
(Designed to be used by operator to note those items that require improvement, modernization/modifications, areas of future expansion, additional required system capabilities, and any other matter that pertains to the evolution of the DSS or aiding the operator.)
ENTRY NO//DATE//TIME//AUTHOR//SUBJECT//CIRCUMSTANCES
»
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

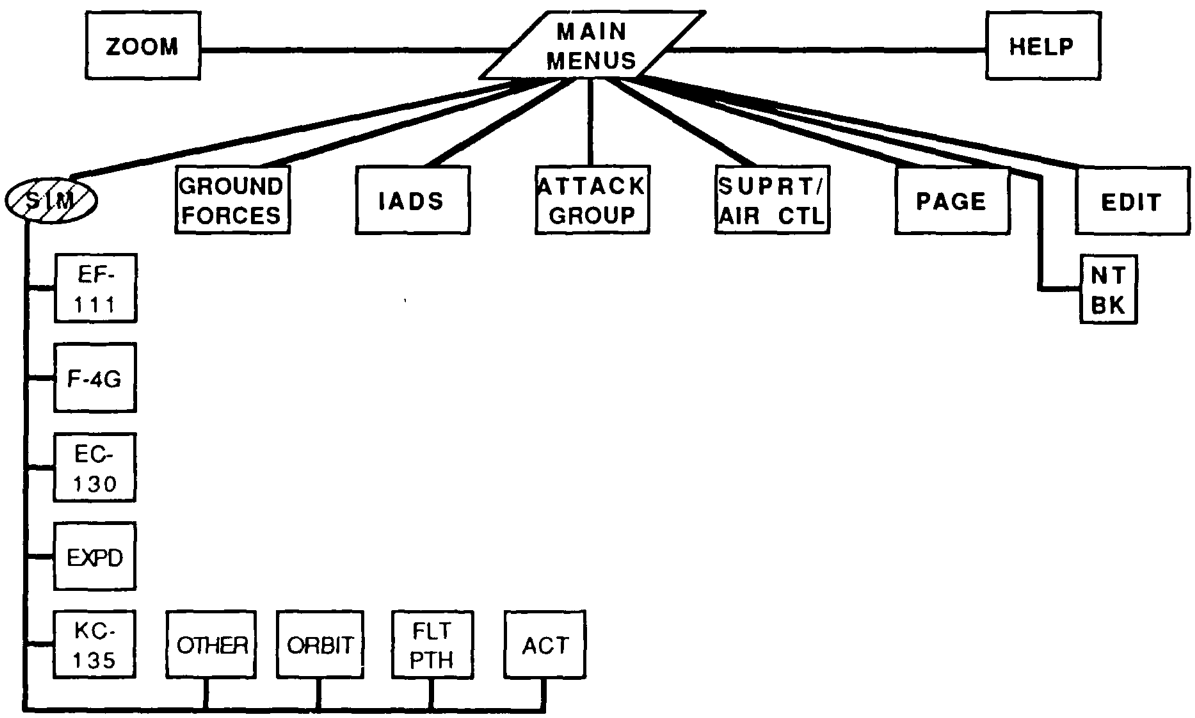

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
NOTE BOOK
HOOK BOOK
NEW
SAVE AS
SAVE
CLOSE
OPEN OLD

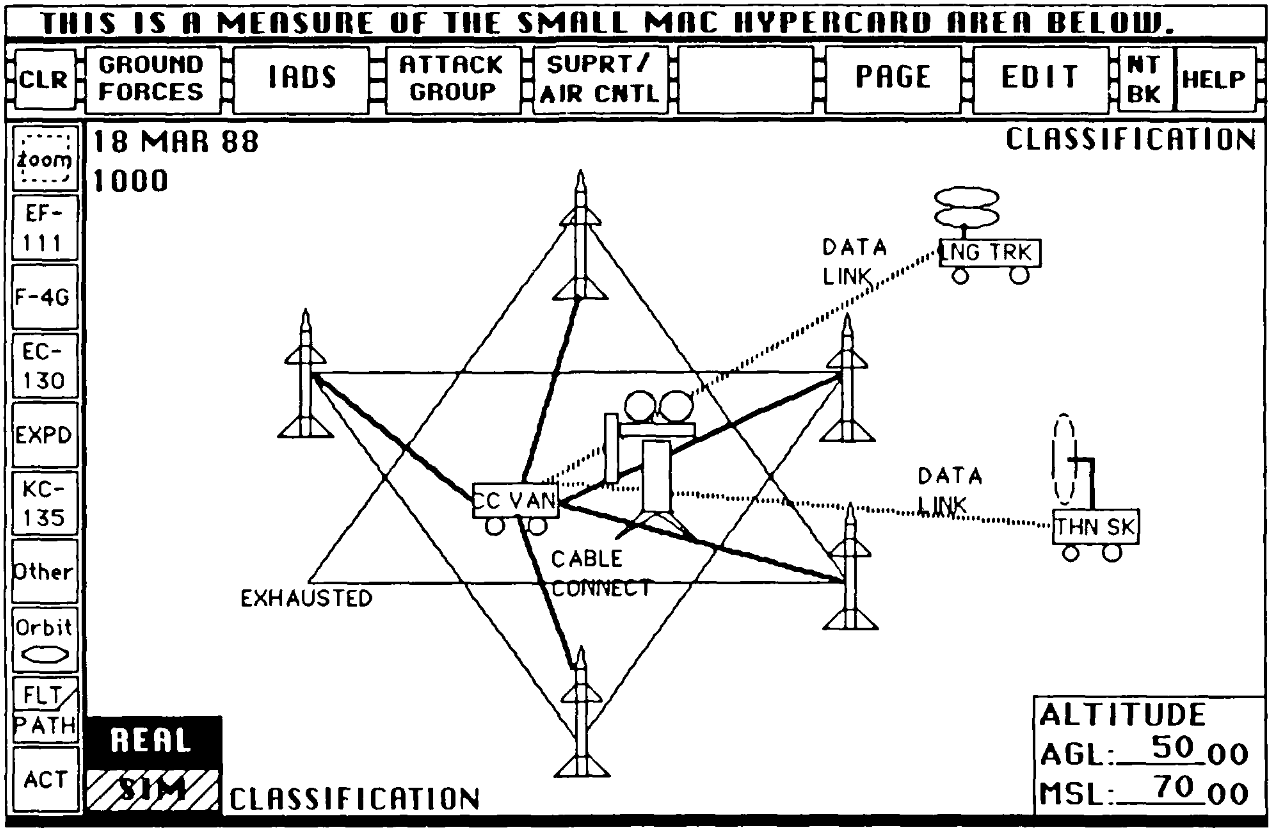
The Simulation Column

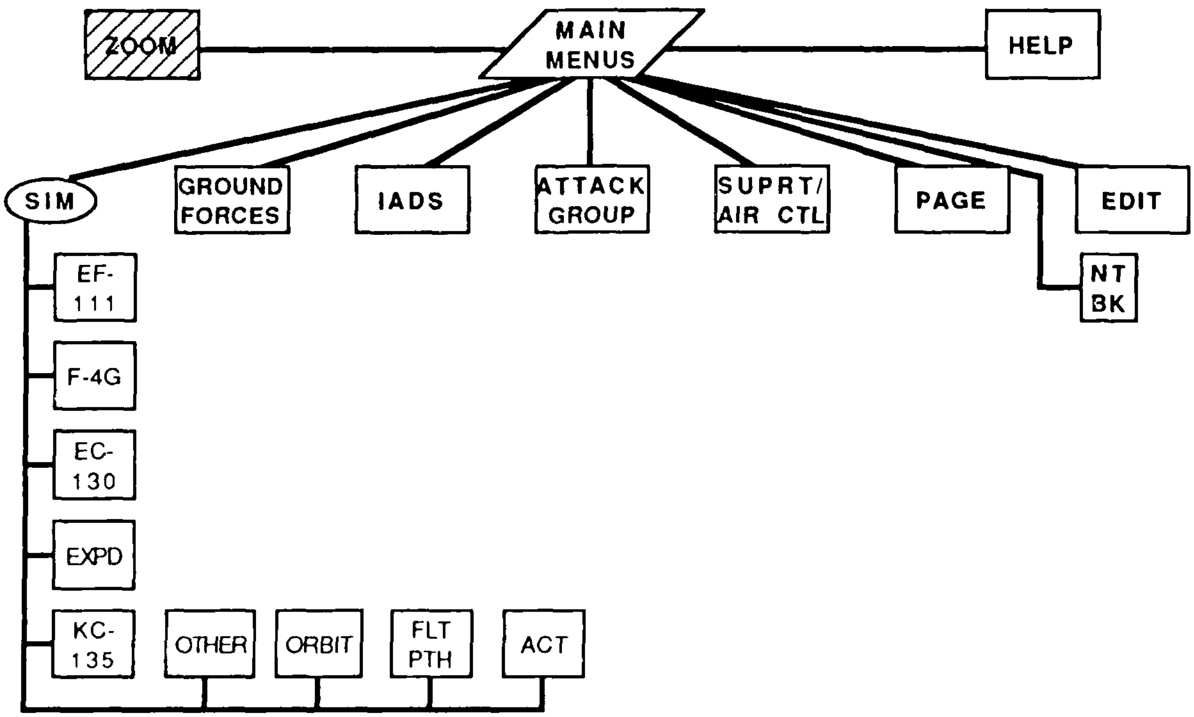
The SIMULATION COLUMN is the vertical column of individual buttons on the left side of the screen. These buttons enable the user to set up and run a simulation using any combination of the available aircraft models. The one exception is the use of the ZOOM button. The ZOOM button allows the user to define an area of interest which is to be expanded to fill the display. The expansion area will fill the screen but the resolution of the terrain is tied to preset DMA (Defense Mapping Agency) map presentation sizes. See the HELP file for a thorough explanation of the representations, operations, memory aids, and control mechanism available to the user on these pages.

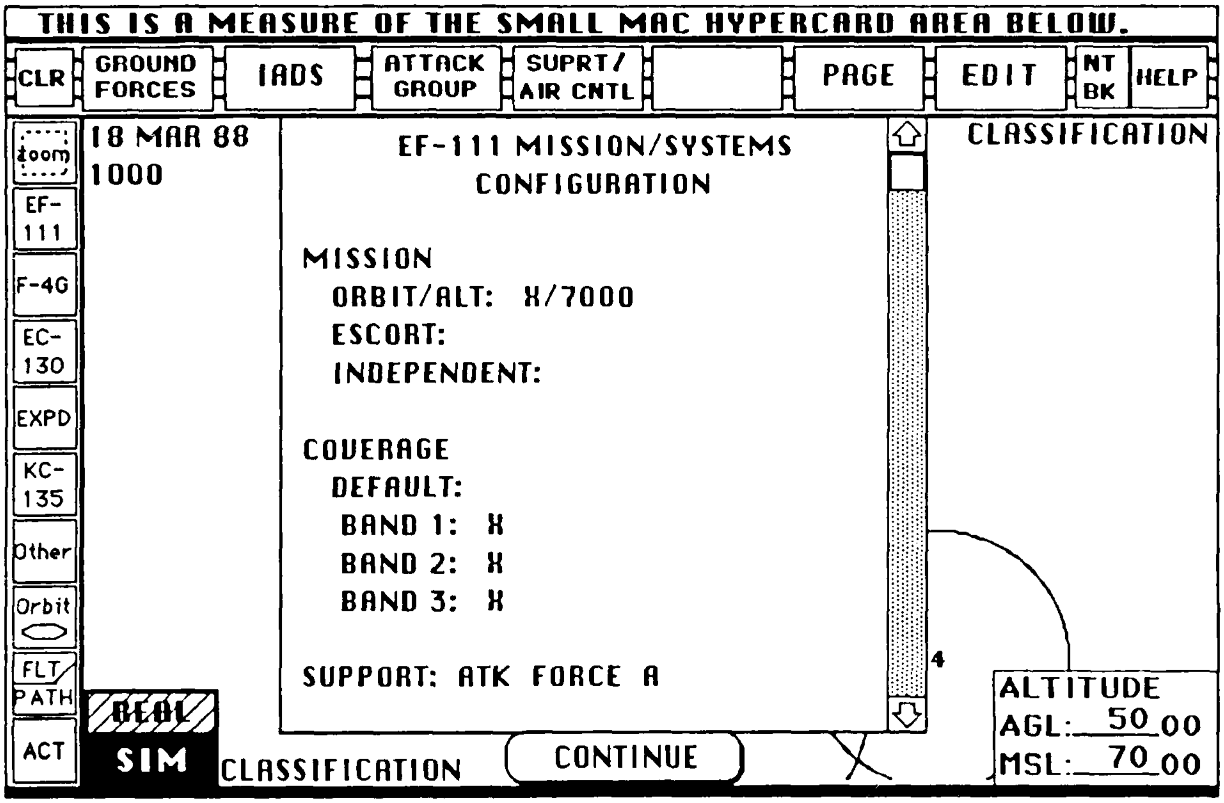



THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

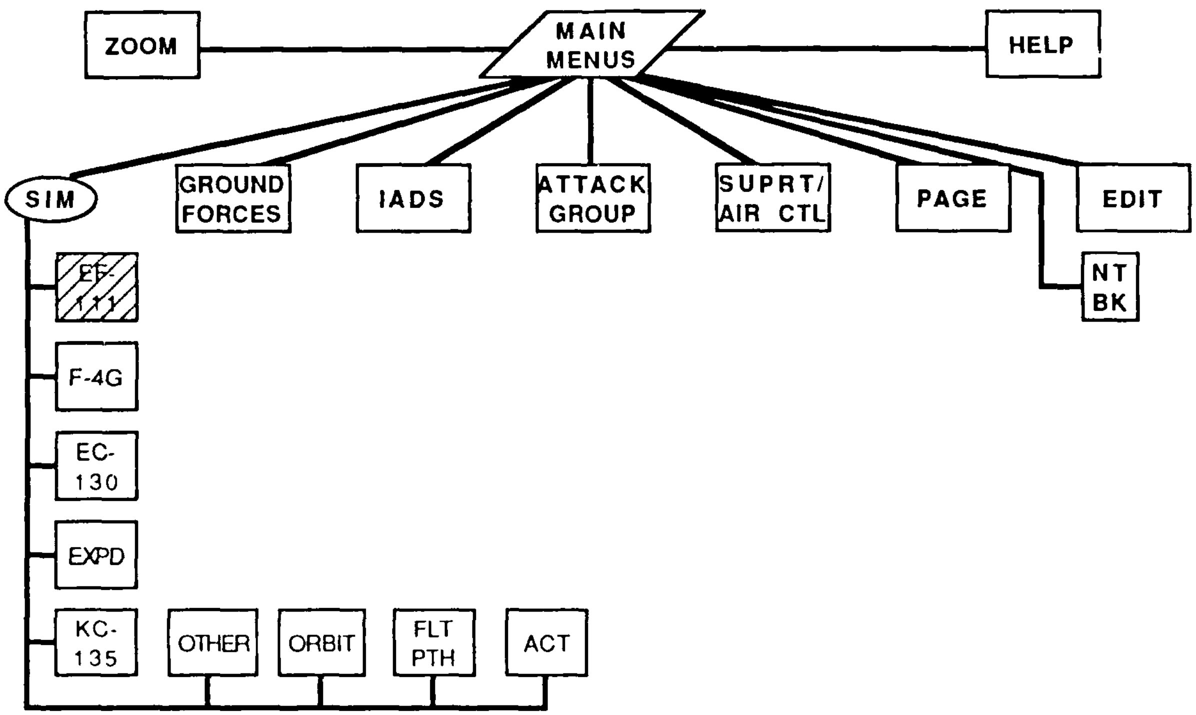

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
EF-111
F-4G
EC-130
EXPD
KC-135
OTHER
ORBIT
FLT PTH
ACT


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
CLASSIFICATION
DATA LINK
LNG TRK
CC VAN
DATA LINK
THN SK
CABLE CONNECT
EXHAUSTED
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00

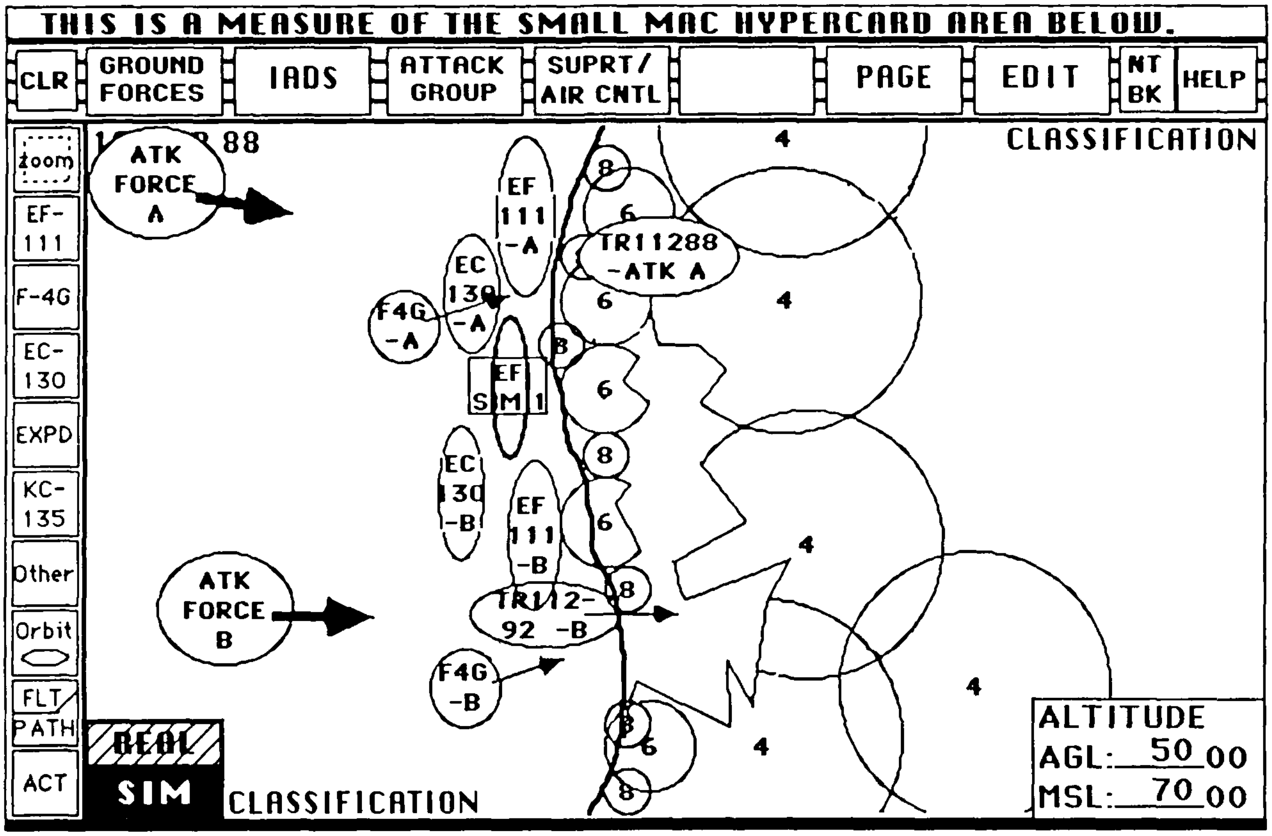

ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
EF-111
F-4G
EC-130
EXPD
KC-135
OTHER
ORBIT
FLT PTH
ACT

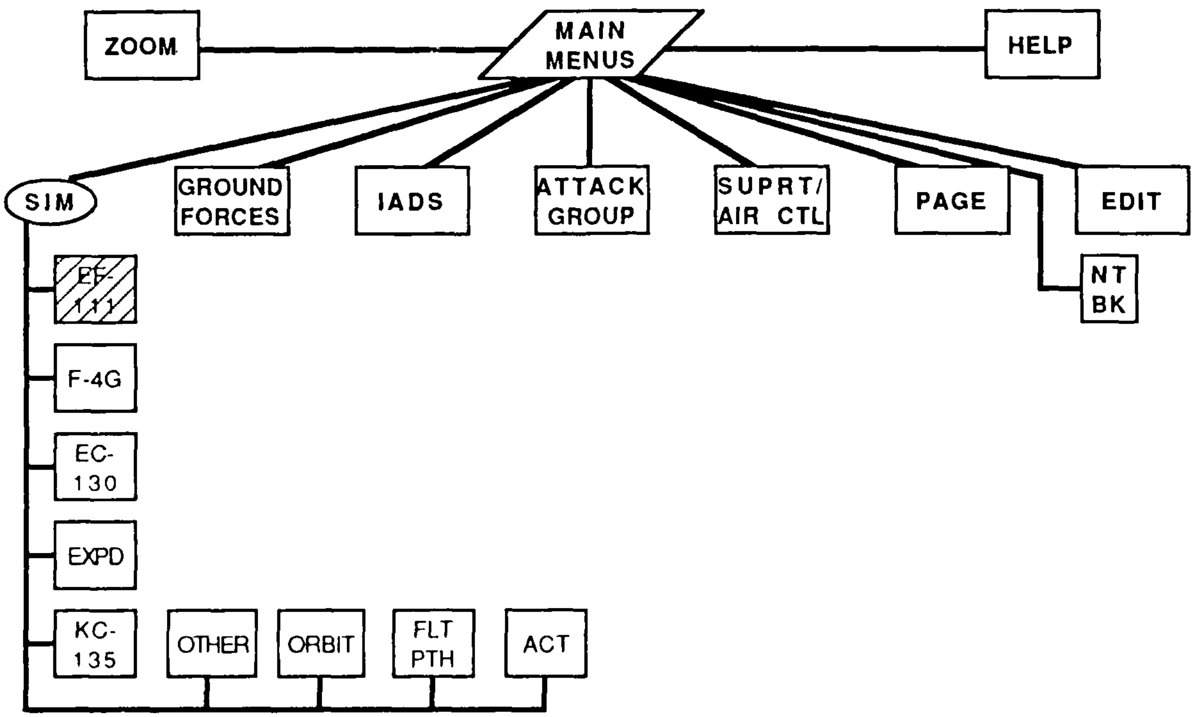


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
18 MAR 88
1000
EF-111 MISSION/SYSTEMS CONFIGURATION
MISSION
ORBIT/ALT: X/7000
ESCORT:
INDEPENDENT:
COVERAGE
DEFAULT:
BAND 1: X
BAND 2: X
BAND 3: X
SUPPORT: ATK FORCE A
CLASSIFICATION
4
ALTITUDE
AGL: 50 00
MSL: 70 00
REAL
SIM
CLASSIFICATION
CONTINUE



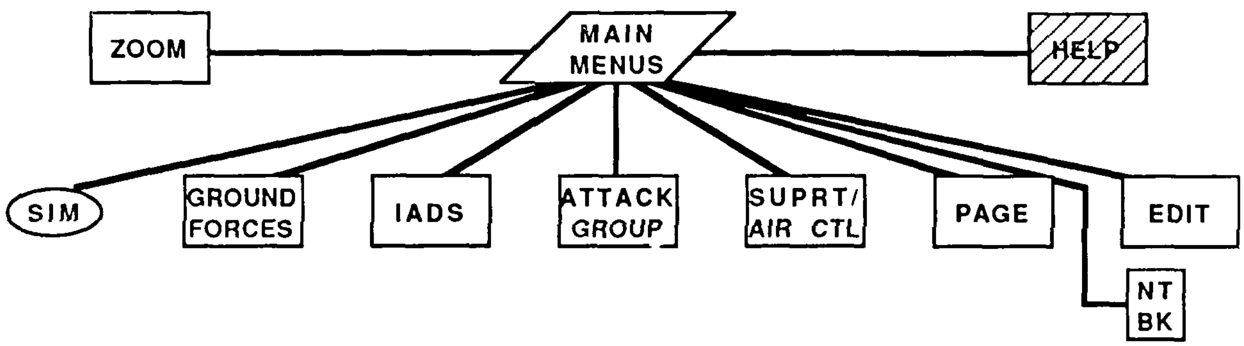
ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
EF-111
F-4G
EC-130
EXPD
KC-135
OTHER
ORBIT
FLT PTH
ACT


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
CLASSIFICATION
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
ATK FORCE A
ATK FORCE B
EF 111 -A
EC 130 -A
F4G -A
TR11288 -ATK A
EF SIM 1
EC 130 -B
EF 111 -B
TR1112-92 -B
F4G -B
REAL
SIM
CLASSIFICATION
ALTITUDE
AGL: 50 00
MSL: 70 00


ZOOM
MAIN MENUS
HELP
SIM
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CTL
PAGE
EDIT
NT BK
EF-111
F-4G
EC-130
EXPD
KC-135
OTHER
ORBIT
FLT PTH
ACT

Help

The HELP menu provides the user with a combined DSS tutorial and individual item Help file. Within each item is an explanation of the representations, operations, memory aids, and control mechanism available to the user. The Help file is structured in generally the same order as on the listed subject contents pages which begin on the next page.



THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

SUBJECT AREA

-ATTACK GROUP MENU ....

-BUTTONS

-- ACT (ACTIVITY) ....

--AIRCRAFT, SIMULATED

---EC-130 ....

---EF-111 ....

---EXPD (EXPENDABLES)

---F-4G ....

---KC-135 ....

---OTHER ....

--CLR (CLEAR) ....

--FLT (FLIGHT) PATH ......

--ORBIT ....

--REAL (REAL-WORLD) ....

--SIM (SIMULATION) .....

SUBJECT AREA

--ZOOM ....

-CLR (CLEAR) BUTTON ....

-DISPLAY, GENERAL NOTES ....

-DISPLAY PRESENTATION CONTROL

--ALTITUDE PERSPECTIVE

(EDIT MENU CONTROL) .....

(SUPRT/AIR CNTL MENU) ...

--DEFAULT SETTING (INITIAL)

--PRESENTATION SET BUTTON

(EDIT MENU CONTROL) .....

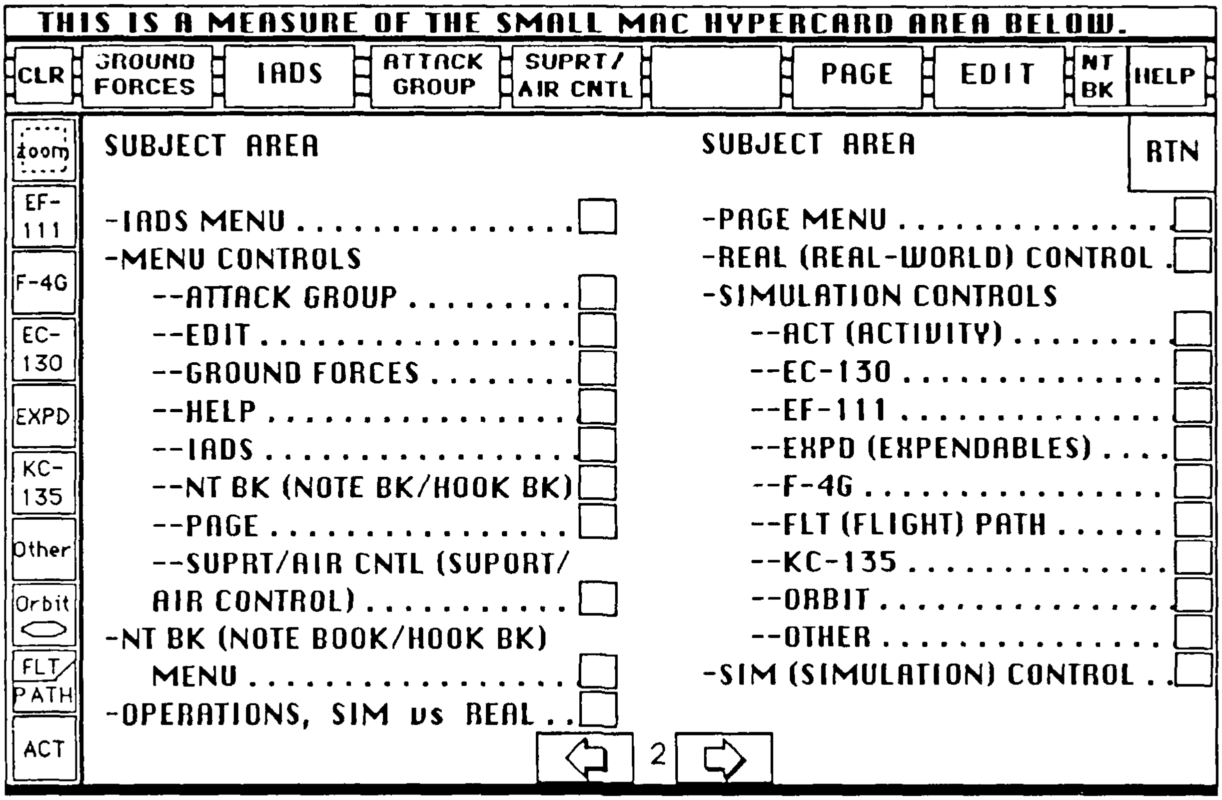
--ZOOM BUTTON ....

-EDIT MENU ....

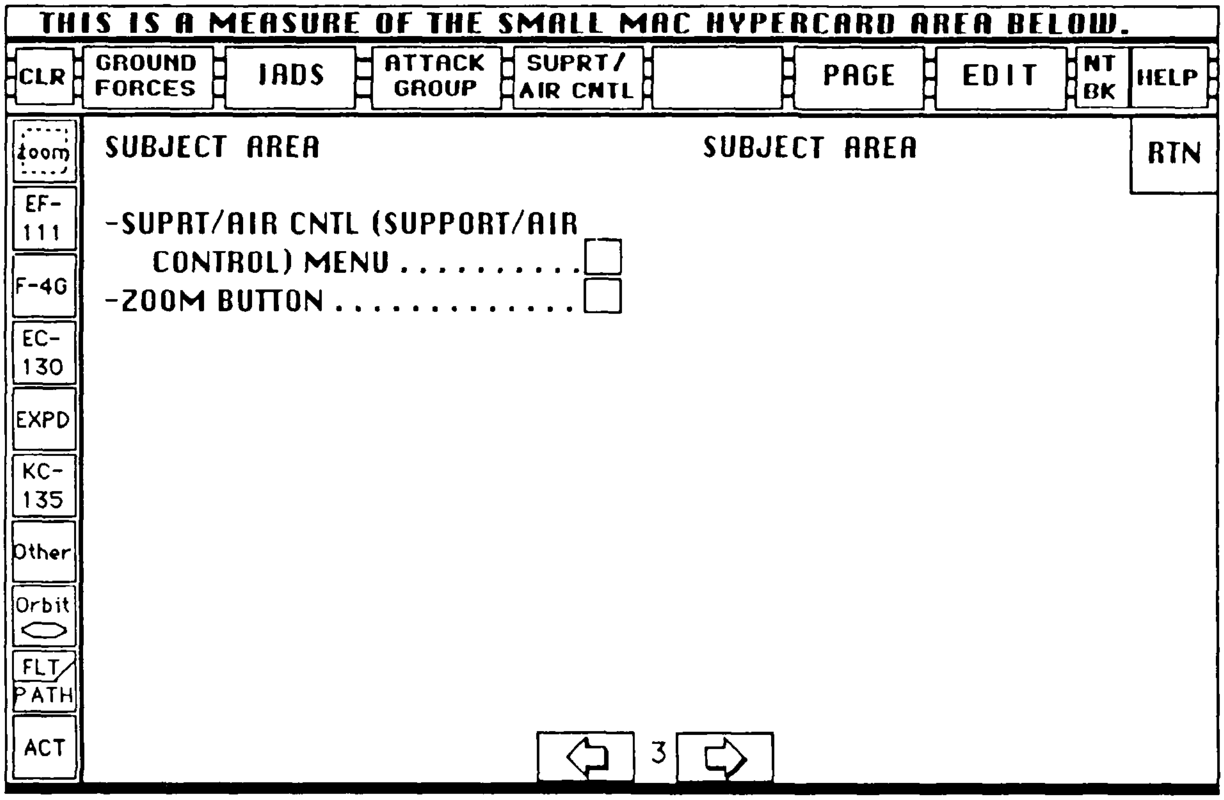
-GROUND FORCES MENU ....

-HELP MENU ....

1



THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
SUBJECT AREA
-IADS MENU
-MENU CONTROLS
--ATTACK GROUP
--EDIT
--GROUND FORCES
--HELP
--IADS
--NT BK (NOTE BK/HOOK BK)
--PAGE
--SUPRT/AIR CNTL (SUPORT/ AIR CONTROL)
-NT BK (NOTE BOOK/HOOK BK) MENU
-OPERATIONS, SIM vs REAL
SUBJECT AREA
RTN
-PAGE MENU
-REAL (REAL-WORLD) CONTROL
-SIMULATION CONTROLS
--ACT (ACTIVITY)
--EC-130
--EF-111
--EXPD (EXPENDABLES)
--F-4G
--FLT (FLIGHT) PATH
--KC-135
--ORBIT
--OTHER
-SIM (SIMULATION) CONTROL
2


THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.
CLR
GROUND FORCES
IADS
ATTACK GROUP
SUPRT/ AIR CNTL
PAGE
EDIT
NT BK
HELP
zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT
SUBJECT AREA
SUBJECT AREA
RTN
-SUPRT/AIR CNTL (SUPPORT/AIR CONTROL) MENU ....
-ZOOM BUTTON ....
3

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

ATTACK GROUP MENU

- ALL

   Shows all BLUE air forces associated with current attack, or strike, forces

- ALL EC

   Shows only the EC air assets currently airborne

- SELECT

   Allows the user to prescribe those air assets to be presented through use of various designations; attack force designation, cell designation, aircraft call sign, EC cell, etc.

- EF-111

   Allows the display of only EF-111 assets currently airborne

4

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

- F-4G
  Allows the display of only F-4G assets currently airborne

- EC-130
  Allows the display of only EC-130 assets currently airborne

- EXPEND (EXPENDABLES)
  Allows the discrete selection and display of expendable assets currently airborne. The selection capability is initially by weapon system and then by any combination of the following: mission number, target number, target priority, active operation time, or by displaying all of the selected system.

- TGTS (ALL)
  Allows the discrete selection and display of all targets assigned to those assets currently airborne. Targets displayed will be both

5

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-ATTACK GROUP MENU: TGTS (ALL) cont.

hard kill and soft kill types. (Hard kill targets are those targets to be physically destroyed. Soft kill targets are those targets that EC/Other capabilities are tasked against.)

Selection of targets to be displayed can be by displaying all targets, by target priority, by type of target kill, by target number, or any combination of the above.

- TGTS (HARD KILL)

Allows the selection and display of targets which are to be physically destroyed. Selection can be for all targets or by any combination of the following: by target priority, by target number, by weapon system tasked against it/them, or time on target (TOT).

- TGTS (SOFT KILL)

Allows the selection and display of targets which are to be

6

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-ATTACK GROUP MENU: TGTS (SOFT KILL) cont.
operationally degraded. Selection can be for all targets or by any combination of the following: by target priority, by target number, by weapon system tasked against it/them, or time of effect on target (TOT).

BUTTONS

- ACT (ACTIVITY) BUTTON

The ACTIVITY button is the last button of the simulation column. (The simulation column is the vertical column of buttons on the left side of the display.) The activity button allows the user to designate that portion of the flight path on which the simulated asset will be active for its mission.

EXAMPLE: First, an orbit is requested, using the Orbit simulation button, and placed at the desired location on the display screen by

7

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT/PATH | ACT

RTN

-BUTTONS: ACT (ACTIVITY) BUTTON cont.

the ECCO. This automatically places the DSS in the simulation mode, awaiting a second activation of the SIM button to initiate the simulation run during which statistics such as attrition are automatically compiled. (The SIM button will blink during the period the DSS remains in the simulation mode.) Second, an aircraft model is selected, again using the desired simulation button. This model aircraft is confiured by the system user and then position over the orbit. The system matches the orbit and the aircraft, selecting an average operational airspeed and an altitude equal to the display's selected presentation altitude or as designated by the user during the aircraft model configuration.

Finally, the user selects the ACT button and moves the pointer to the position on the flight path where the aircraft is to initiate operations. At this point the system user holds the mouse button down and drags the pointer over that portion of the flight path or

8

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-BUTTONS: ACT (ACTIVITY) BUTTON cont.

orbit where the system is to simulate the selected EC asset being active. This acitve area can be broken up by releasing the button, moving to the new location and depressing the mouse button again, dictating another area of activity.

Activity of a selected simulated aircraft can also be determined during the aircraft's mission configuration which occurs immediately after aircraft selection.

- AIRCRAFT, SIMULATED

-- EC-130 BUTTON

The EC-130 button allows the selection and placement by the user of a model which simulates the activities and effects of an EC-130. Upon selecting the button, the DSS automatically drops into the simulation mode, freezing the display with the last presented real-

9

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

--BUTTONS: AIRCRAFT, SIMULATED: EC-130 BUTTON cont.

world information, and awaits the user's command to either initiate simulation, by selecting the SIM button, or return to the real-world mode by selecting the REAL button. (The SIM button will blink during the period the DSS remains in the simulation mode.) Also upon selection of the aircraft button, the aircraft's configuration control panel is automatically presented to the user. Once the model's mission/systems configuration is complete and the CONTINUE button selected, a model representation is presented on the screen for placement by the operator. A FLIGHT PATH OR ORBIT MUST FIRST BE POSITIONED ON THE SCREEN BEFORE THE AIRCRAFT IS PLACED OR THE SIMULATED AIRCRAFT WILL "CRASH." (Selection and placement of a flight path/orbit is done using the FLT PATH or ORBIT simulation buttons.) The simulation is initiated by selecting the SIM button.

10

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-- EF-111 BUTTON

The EF-111 button allows the selection and placement by the user of a model which simulates the activities and affects of an EF-111. Upon selecting the button, the DSS automatically drops into simulation mode, freezing the display with the last presented real-world information, and awaits the user's command to either initiate simulation, by selecting the SIM button, or return to the real-world mode by selecting the REAL button. (The SIM button will blink during the period the DSS remains in the simulation mode.) Also upon selection of the aircraft button, the aircraft's configuration control panel is automatically presented to the user. Once the model's mission/systems configuration is complete and the CONTINUE button selected, a model representation is presented on the screen for placement by the operator. A FLIGHT PATH OR ORBIT MUST FIRST BE POSITIONED ON THE SCREEN BEFORE THE AIRCRAFT IS PLACED OR THE SIMULATED AIRCRAFT WILL "CRASH." (Selection and placement of a

11

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

--BUTTONS: AIRCRAFT, SIMULATED: EF-111 BUTTON cont.
flight path/orbit is done using the FLT PATH or ORBIT simulation buttons.) The simulation is initiated by selecting the SIM button.

-- EXPD (EXPENDABLES) BUTTON

The EXPD button allows the selection and placement by the user of a model which simulates the activities and affects of any of the operational expendable EC assets currently modelled and available on this system. Upon selecting the button, the DSS automatically drops into the simulation mode, freezing the display with the last presented real-world information, and awaits the user's command to either initiate simulation, by selecting the SIM button, or return to the real-world mode by selecting the REAL button. (The SIM button will blink during the period the DSS remains in the simulation mode.) Also upon selecting the expendables button, the user is presented with a list of the available simulated expendable EC

12

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

BTN

--BUTTONS: AIRCRAFT, SIMULATED: EXPD (EXPENDABLES) cont.
systems from which any combination of these systems can be selected for use. Once the systems are selected and the CONTINUE button is pressed, the DSS will present the operator with the mission configuration options for each expendable. After completing the model's mission/systems configuration and the CONTINUE button selected, a model representation is presented on the screen for placement by the operator. A FLIGHT PATH OR ORBIT MUST FIRST BE POSITIONED ON THE SCREEN BEFORE THE AIRCRAFT IS PLACED OR THE SIMULATED AIRCRAFT WILL "CRASH." (Selection and placement of a flight path/orbit is done using the FLT PATH or ORBIT simulation buttons.) The simulation is initiated by selecting the SIM button.

-- F-4G (WILD WEASEL) BUTTON

The F-4G button allows the selection and placement by the user

13

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

--BUTTONS: AIRCRAFT, SIMULATED: F-4G (WILD WEASEL) cont.
of a model which simulates the activities and affects of an F-4G. Upon selecting the button, the DSS automatically drops into simulation mode, freezing the display with the last presented real-world information, and awaits the user's command to either initiate simulation, by selecting the SIM button, or return to the real-world mode by selecting the REAL button. (The SIM button will blink during the period the DSS remains in the simulation mode.) Also upon selection of the aircraft button, the aircraft's configuration control panel is automatically presented to the user. Once the model's mission/systems configuration is complete and the CONTINUE button selected, a model representation is presented on the screen for placement by the operator. A FLIGHT PATH OR ORBIT MUST FIRST BE POSITIONED ON THE SCREEN BEFORE THE AIRCRAFT IS PLACED OR THE SIMULATED AIRCRAFT WILL "CRASH." (Selection and placement of a flight path/orbit is done using the FLT PATH or ORBIT simulation

14

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT/PATH | ACT

RTN

--BUTTONS: AIRCRAFT, SIMULATED: F-4G (WILD WEASEL) cont.

buttons.) The simulation is initiated by selecting the SIM button.

-- KC-135 BUTTON

The KC-135 button allows the selection and placement by the user of a model which simulates the activities and affects of an KC-135. Upon selecting the button, the DSS automatically drops into simulation mode, freezing the display with the last presented real-world information, and awaits the user's command to either initiate simulation, by selecting the SIM button, or return to the real-world mode by selecting the REAL button. (The SIM button will blink during the period the DSS remains in the simulation mode.) Also upon selection of the aircraft button, the aircraft's configuration control panel is automatically presented to the user. Once the model's mission/systems configuration is complete and the CONTINUE button selected, a model representation is presented on the screen for

15

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

RTN

--BUTTONS: AIRCRAFT, SIMULATED: KC-135 BUTTON cont.

placement by the operator. A FLIGHT PATH OR ORBIT MUST FIRST BE POSITIONED ON THE SCREEN BEFORE THE AIRCRAFT IS PLACED OR THE SIMULATED AIRCRAFT WILL "CRASH." (Selection and placement of a flight path/orbit is done using the FLT PATH or ORBIT simulation buttons.) The simulation is initiated by selecting the SIM button.

-- OTHER BUTTON

The OTHER button allows the selection and placement by the user of a model which simulates the activities and affects of selected other air assets currently modelled and available on this system. Upon selecting the button, the DSS automatically drops into the simulation mode, freezing the display with the last presented real-world information, and awaits the user's command to either initiate simulation, by selecting the SIM button, or return to the real-world mode by selecting the REAL button. (The SIM button will blink during

16

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

--BUTTONS: AIRCRAFT, SIMULATED: OTHER BUTTON cont.
the period the DSS remains in the simulation mode.) Also upon selecting the expendables button, the user is presented with a list of the available simulated aircraft from which any combination of these systems can be selected for use. Once the systems are selected and the CONTINUE button is pressed, the DSS will present the operator with the mission configuration options for each selected aircraft. After completing the model's mission/systems configuration and the CONTINUE button selected, a model representation is presented on the screen for placement by the operator. A FLIGHT PATH OR ORBIT MUST FIRST BE POSITIONED ON THE SCREEN BEFORE THE AIRCRAFT IS PLACED OR THE SIMULATED AIRCRAFT WILL "CRASH." (Selection and placement of a flight path/orbit is done using the FLT PATH or ORBIT simulation buttons.) The simulation is initiated by selecting the SIM button.

17

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

- CLR (CLEAR) BUTTON

Selection of the CLEAR button resets the display to its turn-on/default setting. The turn-on/default setting shows only the FEBA, mobile SAMs, and each SAM's maximum lethal missile range.

- FLT (FLIGHT) PATH BUTTON

Selection of the FLT PATH button allows the operator to designate where a model aircraft will fly during a simulation. Upon selecting the button, the DSS automatically drops into the simulation mode, freezing the display with the last presented real-world information, and awaits the user's command to either initiate simulation, by selecting the SIM button, or return to the real-world mode by selecting the REAL button. (The SIM button will blink during the period the DSS remains in the simulation mode.) To define a flight path, the operator moves the cursor/pointer to the desired start point of the model aircraft's route at the start of the simulation

18

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-BUTTONS: FLT (FLIGHT) PATH BUTTON cont.

and gives the mouse a single click. This will anchor the path to that point. The operator then moves the pointer along the desired flight path to the next turn point. As this is being done, the path is laid out as a straight line from the anchor point to the pointer tip. At the desired turn point, the operator gives the mouse another click which anchors the flight path as a straight line between this point and the last instance the flight path was anchored. At the end of the desired flight path the operator double clicks the mouse on the desired end point and the system then anchors the line of flight at that point and terminates the route. A FLIGHT PATH OR ORBIT MUST FIRST BE POSITIONED ON THE SCREEN BEFORE THE SIMULATED AIRCRAFT IS PLACED OR THE AIRCRAFT WILL "CRASH."

- ORBIT BUTTON

Selection of the ORBIT button allows the operator to designate

19

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-BUTTONS: ORBIT BUTTON cont.

where a model aircraft will fly an orbit during a simulation. Upon selecting the button, the DSS automatically drops into the simulation mode, freezing the display with the last presented real-world information, and awaits the user's command to either initiate simulation, by selecting the SIM button, or return to the real-world mode by selecting the REAL button. (The SIM button will blink during the period the DSS remains in the simulation mode.) To define the orbit area, the operator moves the cursor/pointer to the desired point of the model aircraft's orbit at the start of the simulation and *gives the mouse a double click. This will anchor the center of the* orbit to that point. A FLIGHT PATH OR ORBIT MUST FIRST BE POSITIONED ON THE SCREEN BEFORE THE SIMULATED AIRCRAFT IS PLACED OR THE AIRCRAFT WILL "CRASH."

20

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

- REAL (REAL-WORLD) BUTTON

The REAL button performs two fuctions. The first is to inform the user of the system that the DSS is operating in a real-world mode, using actual operational inputs to generate the presentations and information being displayed. It does this by being highlighted while the SIM button is simultaneously subdued.

The second function is to enable to DSS operator to instantly terminate a simulation by using the pointer/cursor, commanded by a mouse, to click on the REAL button. When the REAL button is activated in this manner it highlights itself, all simulation is terminated (the simulation data and statistics are automatically stored for later use), and the display is updated to reflect current real-world information.

- SIM (SIMULATION) BUTTON

The SIM button performs two functions. The first is to inform the

21

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-BUTTONS: SIM (SIMULATION) BUTTON cont.

observer that the system is operating in a simulation mode and that the displayed information is being computer originated (though the general background may have been the last real-world information received prior to begining the simualtion run). It indicates this when the SIM button is highlighted and the REAL button is subdued.

The second function is to place the system into a simulation mode and then initiate a simulation run after the EC asset models have been placed and readied for the run. To place the DSS into a simulation mode requires that the SIM button be clicked on by the cursor/pointer of the mouse or that one of the simulation models be requested as explained under each of the models. To initiate a simulation run requires that the SIM button be clicked on by the cursor regardless of how the DSS was placed in the simulation mode.

22

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

- ZOOM BUTTON

The ZOOM button allows the operator to discretely select and enlarge subportions of the area being viewed as well as returning to the original large-area overview. This is done by the user clicking once on the ZOOM button and the moving the cursor to the area that will be a corner of the area to be boxed. After depressing and holding down on the botton on the mouse, the operator drags the cursor diagnolly across the area to be enlarged. As the cursor is being dragged across the area, the area will be encompassed by a box whose sides are of dashed lines. Once the area is encompassed and the user lets up on the mouse button, the area will expand to fill the display screen. This can be done repeatedly to gain finer and finer small-area detail.

To return directly to the original display area, as defined using the EDIT menu's PRESENT (Presentation) SET UP, use the CLR button or, if there has been only one expansion, double click on the ZOOM

23

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-BUTTONS: ZOOM BUTTON cont.

button. Double clicking on the ZOOM button will allow the user to "walk" up the expansions in the same order and using the same bondaries as were used when defining the smaller ares to be viewed.

DISPLAY, GENERAL NOTES

- INITIAL START-UP DISPLAY: Whenever the system is initially powered up or the CLR button is hit, the screen presentation displayed to the viewer will be what is termed the default or initial display. This initial screen presentation will consist of the FEBA, the positions and identification of the enemy mobile SAM systems, and rings around each of the SAMs which represent the maximum range for the associated missile. Additionally, the initial altitude perspective of the DSS will be FL450, which will be displayed, along with its AGL counterpart, in the ALTITUDE box in the lower right hand

24

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT

RTN

-DISPLAY, GENERAL NOTES: INITIAL START-UP DISPLAY cont. corner of the display. Positioning of the SAMs will be based on the latest available real-time intelligence inputs and updated using this same input source. The initial range of the SAMs will be based on the default starting altitude of FL450 but will be tied to the altitude perspective as shown in the ALTITUDE box and requested under the PRESENT (PRESENTATION) SET UP item of the EDIT menu.

- GENERAL CONTROL GROUPINGS (SIM vs OPERATIONAL): The DSS control features, the MENU headings and the individual BUTTONs, are roughly divided into two categories. The first category is those controls that allow the user to select and display actual real-world information. This category includes all the MENU buttons across the top of the display as well as the ZOOM and REAL buttons.

The second category is those controls that allow the user to set up, run, and evaluate a simulation. This includes the controls on

25

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-DISPLAY, GENERAL NOTES: GENERAL CONTROL GROUPINGS cont. the left side of the display, except the ZOOM button, and the SIM button.

- PAGES: The purpose of this decision support system is to allow the Electronic Combat Coordination Officer to develop and determine the comparitive worth of various alternate plans for the retasking if electronic combat assets. Consequently, there are various tools required to give the ECCO this ability: an ability to determine what has changed and the impact of that change on the current plan (thereby leading the need to retask), an ability to assist the ECCO in generating alternative retasking plans, and an ability to evaluate these alternatives. These requirements are met by the tools distributed on the various pages supported by this DSS.

The OVERVIEW page is the page currently supported and gives the user the capability monitor events and set up and run alternative

26

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-DISPLAY, GENERAL NOTES: PAGES cont.

retasking plans using simulation. Once implemented, the ATTRITION vs DAMAGE page will support the ECCO's ability to assess the impact of any change and the effects versus the costs of the alternative retasking plans. The remaining two pages, FREQUENCY MANAGEMENT and AIRSPACE MANAGEMENT, once implemented, will also support both the planning of alternative missions and the ability to further assess the impact of those alternate plans on those two areas.

EDIT MENU

The EDIT menu is divided into two sections. The first, or upper, section provides the tools needed for the construction of a simulation or taking a "snap shot" of a display and modifying it once it has been transferred to the HOOK BOOK. The second, or lower,

27

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-EDIT MENU: COPY cont.

clicking the mouse button while the cursor is inside the confines of the box will simultaneously store a copy of the object in the single-item memory, get rid of the box, and return the cursor to normal operations. The original image will be unaffected.

- CUT

Enables the selection of a portion of the display and its deletion from the display. CUT fuctions identically to COPY, only the final effects differ. The user selects the menu item, positions the cursor near the object to be copied, and, after first depressing the mouse button and holding it down, drags the cursor diagonally across the object. As the cursor is being drawn across the object a box is formed around the target. Upon releasing the mouse button the box stops forming at that point. Double clicking the mouse button while the cursor is inside the confines of the box will simultaneously

29

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-EDIT MENU: CUT cont.

delete the encompassed portion of the image, get rid of the box, and return the cursor to normal operations.

- DUPLICATE

Enables the selection of a portion of the display and its immediate duplication. The user selects the menu item, positions the cursor near the object to be copied, and, after first depressing the mouse button and holding it down, drags the cursor diagonally across the object. As the cursor is being drawn across the object a box is formed around the target. Upon releasing the mouse button the box stops forming at that point and a duplicate of the encompassed area, slightly offset from the original, is presented. The original image will be unaffected. The duplicate can be moved by placing the cursor within the confines of the duplicate, holding down the mouse button, and dragging the duplicate to its new

30

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4C | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-EDIT MENU: DUPLICATE cont.

location. Releasing the mouse button will cause the duplicate to remain at the last location it was at while the mouse button was being held down. Double clicking the mouse button on the duplicate will cause the duplicate to be "pasted" to that position.

- PASTE

Enables the movement and permanent positioning of data that has been been obtained using CUT or COPY. Selecting PASTE after having obtained an item using CUT or COPY will cause the immediate appearence of the item on the screen. The item can be moved by placing the cursor within its confines, holding down the mouse button, and dragging the item to its new location. Releasing the mouse button will cause the item to remain at the last location it was at while the mouse button was being held down. Double clicking the mouse button on the item will cause the item to be

31

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-EDIT MENU: PASTE cont.
"pasted" to that position.

- SELECT SCREEN

Enables the entire display to be selected for processing such as cutting out, copying, duplicating, etc. To function, first select the menu item SELECT SCREEN and then the menu item for the desired function. On selecting SELECT SCREEN the entire display will be surrounded by the same box seen when using CUT, COPY, or DUPLICATE. The desired process, such as CUT, will be enacted immediately upon selecting the desired menu item.

- SHOW VECTOR

Selecting the menu item, SHOW VECTOR, enables the user to veiw information about a selected force or item in the form of a column of data below that force or item. This information vector is

32

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-EDIT MENU: SHOW VECTOR cont.

obtained by placing the cursor on the item of interest and holding down the mouse button. The information will be withdrawn once the button is released.

- PRESENT (PRESENTATION) SET UP

This menu item allows the customizing of the screen display with respect to both the altitude/location perspective assumed for the display presentation and the forces/force boundaries presented on the display.

-- ALTITUDE OF DISPLAY

This item allows the user to define in one hundred foot intervals the altitude that the DSS will assume for its perspective. This will determine such things as the radii of SAM rings when calculating their range for presentation on the display and the initial altitude to

33

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

--EDIT MENU: PRESENT SET UP: ALTITUDE OF DISPLAY cont.
display when requesting to see the management of the air space under the AIR SPACE CONTROL, ALL menu item. This altitude can be measured in either MSL (Mean Sea Level) or AGL (Above Ground Level).

-- DISPLAY CENTER

This item allow the operator to select the center of the system's display and the area of coverage. Multisensor input can enable the system to display entire theaters, though of course at a very low resolution of forces.

-- SHOW FEBA (FORWARD EDGE OF THE BATTLE AREA)

This selection allows the user to either show or not show the FEBA on the DSS display.

34

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-EDIT MENU: PRESENT SET UP cont.

-- FORCES / FORCE BOUNDRIES

This menu item enables the operator to customize the display presentation with respect to the level of the forces shown and the force boundries presented. The two areas are directly related: with Battalions selected as the force level for presentation, then the force boundries that will be displayed will be Battalion boundaries. There is also the capability to display none of the boundaries, all of the boundaries, or allow the system to determine the level of forces and force boundaries to display by selecting the DEFAULT option. This latter option will result in the system selecting and displaying forces based on the area presentation of the display. The smaller the display area, the lower the level of the force displayed. This is the system initial power-up setting.

35

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT/ PATH | ACT

GROUND FORCES MENU

RTN

Enables the control of the display of ground forces.

- ALL

Causes the display of all ground forces at the unit force level defined by the EDIT: PRESENTation SET UP menu item. The initial, or power-up, selection of the force level for the DSS is the system's DEFAULT setting (see EDIT MENU: PRESENTation SET UP: FORCES / FORCE BOUNDARIES). This is the initial selection for display of forces.

- US

Causes the display of all US ground forces at the unit force level defined by the EDIT: PRESENTation SET UP menu item. The initial, or power-up, selection of the force level for the DSS is the system's DEFAULT setting (see EDIT MENU: PRESENTation SET UP: FORCES / FORCE

36

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-GROUND FORCES MENU: US cont.
BOUNDRIES).

- NATO

Causes the display of all NATO ground forces at the unit force level defined by the EDIT: PRESENTation SET UP menu item. The initial, or power-up, selection of the force level for the DSS is the system's DEFAULT setting (see EDIT MENU: PRESENTation SET UP: FORCES / FORCE BOUNDRIES).

- USSR

Causes the display of all USSR ground forces at the unit force level defined by the EDIT: PRESENTation SET UP menu item. The initial, or power-up, selection of the force level for the DSS is the system's DEFAULT setting (see EDIT MENU: PRESENTation SET UP: FORCES / FORCE BOUNDARIES).

37

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT/ PATH | ACT

RTN

GROUND FORCES MENU cont.

- WP (WARSAW PACT)

Causes the display of all WP ground forces at the unit force level defined by the EDIT: PRESENTation SET UP menu item. The initial, or power-up, selection of the force level for the DSS is the system's DEFAULT setting (see EDIT MENU: PRESENTation SET UP: FORCES / FORCE BOUNDARIES).

- OTHER

Causes the display of all ground forces of the selected country(ies) at the unit force level defined by the EDIT: PRESENTation SET UP menu item. The user must make an active selection in order to display any one of the OTHER countries or any combination of those listed. No forces of the countries listed under OTHER will initially be displayed. The initial, or power-up, selection of the force level for the DSS is the system's DEFAULT setting (see

38

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-GROUND FORCES MENU: OTHER cont.
EDIT MENU: PRESENTation SET UP: FORCES / FORCE BOUNDARIES).

HELP

Selection of the HELP menu brings the user to the first page of the HELP file's table of contents. The selection of any of these item's buttons will take the user directly to the information for that subject area.

IADS (INTEGRATED AIR DEFENSE SYSTEM) MENU

This menu enables both the real time monitoring of all aspects of an enemy IADS operations and the qualitative assessment of the impact of EC operations on the IADS. These capabilities are applicable in either the REAL (real world) or the SIM (simulation)

39

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

IADS (INTEGRATED AIR DEFENSE SYSTEM) cont.
modes.

- ALL

Enables the presentation of all the major components of an IADS as well as their major characteristics: the air threat, the SAM system, AAA systems, the ranges of their weapons and radars, and the command and control (C2) interconnectivity of the system.

- AIR

When implemented, this menu item will enable the display of the enemy air threat environment. Details of this proposed display are still being developed.

- SAM

The seletion of this menu item enables the presentation of all

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CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT/ PATH | ACT

RTN

-IADS (INTEGRATED AIR DEFENSE SYSTEM): SAM cont.
SAM systems in the area presentation coverage. This includes both fixed and mobile SAMs unless this menu item is changed using the FIXED or MOBILE modifiers. In this latter case, the selection of one of the modifiers will eliminate the presentation of the other class of systems. The presentation of SAMs will include the system's numerical designation and its weapon's maximum leathal range given the altitude perspective of the DSS (see EDIT: PRESENTation SET UP).

- AAA

AAA systems will be shown in the same manner and with the same modifications and restrictions as are SAMs. This portion of the system is not currently ready for display or implementation.

41

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CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

IADS (INTEGRATED AIR DEFENSE SYSTEM) cont.

- FIXED and MOBILE

These menu items are selected prior to the selection of the catagories they modify, SAM and AAA, and do not have an independent function. They exist solely to modify the ground threat categories.

- SAM RNG (RANGE) and AAA RNG (RANGE)

Enables the display of weapon ranges for both types of threat. This is the default category of display during most selections to display either threat. Selection of the RNG menu item will automatically display all classes of the type threat requested, i. e. SAMs, with the lethal range of each system, given the altitude perspective of the DSS at the time.

42

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CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

IADS (INTEGRATED AIR DEFENSE SYSTEM) cont.

- S (SAM)-RADAR and A (AAA)-RADAR

Enables the display of probability of detection ranges for both types of threat. These ranges are base on the radar cross section of the aircraft and the percent probability selected as the probability of detection. The default probability of detection is 50%. Other probabilities for detection may be set by annotating the querey page that appears upon the user selecting this menu item. Once the probability of detection is set, the system will automatically display all classes of the type threat requested, i. e. SAMs, with the range of each system, given the altitude perspective of the DSS at the time.

- EW (EARLY WARNING RADARS) and GCI (GROUND CONTROL INTERCEPT RADARS)

Enables the display of probability of detection ranges for both

43

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CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom · EF-111 · F-4G · EC-130 · EXPD · KC-135 · Other · Orbit · FLT PATH · ACT

RTN

-IADS (INTEGRATED AIR DEFENSE SYSTEM): EW and GCI cont. types of radar systems. These ranges are base on the radar cross section of the aircraft and the percent probability selected as the probability of detection. The default probability of detection is 50%. Other probabilities for detection may be set by annotating the querey page that appears upon the user selecting this menu item. Once the probability of detection is set, the system will automatically display all sites of the type radar requested and their associated detection range ring, given the altitude perspective of the DSS at the time.

- C2 (COMMAND AND CONTROL)

The selection of this menu item allows the depiction of the enemy IADS command and control interconnectivity, primarily in the form of communications interconnectivity. It enables both the real-time real-world monitoring and evaluation of effects due to EC

44

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CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-IADS (INTEGRATED AIR DEFENSE SYSTEM): C2 cont. operations as well as the monitoring and evaluation of the effectiveness of proposed EC operations using simulation techniques. Upon selecting this menu item there will be displayed the interconnectivity of the displayed IADS components using black lines to depict cable connection between points and fuzzy gray lines to indicate HF/VHF/UHF connections. Disruption of these connections will be shown as breaks in the lines: hard wire disruptions will be depicted as a single large break at about the midpoint of the connection; disruption of radio connections will be depicted as increasingly widening dashed lines to depicted increasing degrees of deterioration of the communications link.

45

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT / AIR CNTL | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

NT BK (NOTE BOOK / HOOK BOOK) MENU

RTN

The NOTE BOOK feature of this menu allows the user to put aside personal notes for purposes such as a memory aid. The HOOK BOOK feature allows the direct input of suggestions to the design team for the improvement and evolution of the DSS as an interagal part of the adaptive design process. The importance of HOOK BOOK entries is that they are the basis of requirements for future modules of the evolving DSS and will therefore determine the future capabilities and characteristics of the DSS as it grows into its various other areas of operations.

The second portion of the menu consists of the controls available to the operator for the storage and access of the NOTE BOOK and HOOK BOOK files.

46

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

NT BK (NOTE BOOK / HOOK BOOK) MENU cont.

- NEW

Generates a new NOTE BOOK or HOOK BOOK file ready to accept user inputs. Requires that NOTE BOOK or HOOK BOOK have been selected first.

- OPEN OLD

Allows the accessing of established files.

- CLOSE

Closes the file currently working in. The system will automatically ask if you would like to store unsaved changes and will require you to name those files not previously named.

- SAVE

Enables the storage of information without having to close the

47

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

RTN

-NT BK (NOTE BOOK / HOOK BOOK) MENU: SAVE cont.
file you are currently working in. The system will automatically ask if you would like to store unsaved changes and will require you to name those files not previously named.

- SAVE AS

Enables the storage of information in a new file without having to close the current file. The system will automatically ask if you would like to store unsaved changes.

SUPRT (SUPPORT) / AIR CNTL (CONTROL) MENU

The items of this menu are primarily designed to support information needs concerning support resources, assessing air space usage to support retasking mission generation, and operational guidence. Also, the vast majority of these aids have

48

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CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom
EF-111
F-4G
EC-130
EXPD
KC-135
Other
Orbit
FLT PATH
ACT

RTN

SUPRT (SUPPORT) / AIR CNTL (CONTROL) MENU cont.

not been constructed and therefore are not shown at this time. An initial rough proposal will be given for the porpose of generating comments on which to build the requirements for these aids.

- BASES, AIR REFUEL, SAR (SEARCH AND RESCUE)

Gives information on the status and support capabilities of bases, air refueling assets, and SAR assets. The operator is able to access data using various sort requirements. The information required on within these areas to support the ECCO's retasking mission have not been determined. Suggestions as to the information needed by the ECCO to do retasking are welcomed.

49

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR	GROUND FORCES	IADS	ATTACK GROUP	SUPRT/ AIR CNTL		PAGE	EDIT	NT BK	HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT PATH | ACT

SUPRT (SUPPORT) / AIR CNTL (CONTROL) MENU cont.
- AIR SPACE CNTL (CONTROL)

RTN

-- ALL

Enables the simultaneous display of all listed uses of airspace over the battlefield. These uses include minimum risk ingress/ egress corridors, airspace used for artillery and naval gunfire, and the command status of the Air Defense Artillery covering a given area of airspace. All AIR SPACE CNTL pages give the operator active, continuous control of the altittude being used to drive the DSS display of the airspace usage as well as an identical control to control the time, from the present to 24 hours in the future, of the presentation. This allows the user the ability to view airspace usage as it changes vertically with altitude and as it changes (planned) with time.

50

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT/PATH | ACT

RTN

SUPRT / AIR CNTL MENU: AIR SPACE CNTL cont.

-- CORRIDORS

Enables the display of current and planned minimum risk ingress/ egress corridors. Additionally, these can be viewed over altitude and time. All AIR SPACE CNTL pages give the operator active, continuous control of the altittude being used to drive the DSS display of the airspace usage as well as an identical control to control the time, from the present to 24 hours in the future, of the presentation. This allows the user the ability to view airspace usage as it changes vertically with altitude and as it changes (planned) with time.

-- ARTY (ARTILLERY) / NAVAL (gunfire)

Enables the display of those airspaces being used for or planned for allied artillery and naval gunfire. Additionally, these can be viewed over altitude and time. All AIR SPACE CNTL pages give the

51

THIS IS A MEASURE OF THE SMALL MAC HYPERCARD AREA BELOW.

CLR | GROUND FORCES | IADS | ATTACK GROUP | SUPRT/ AIR CNTL | | PAGE | EDIT | NT BK | HELP

Zoom | EF-111 | F-4G | EC-130 | EXPD | KC-135 | Other | Orbit | FLT/ PATH | ACT

RTN

--SUPRT / AIR CNTL MENU: ARTY / NAVAL (gunfire) cont.
operator active, continuous control of the altittude being used to drive the DSS display of the airspace usage as well as an identical control to control the time, from the present to 24 hours in the future, of the presentation. This allows the user the ability to view airspace usage as it changes vertically with altitude and as it changes (planned)with time.

-- ROEs, CMD GUID (COMMAND and COMMANDER'S GUIDENCE), and MSN OBJ (MISSION OBJECTIVES)

These are computer-based documents set up to allow the easy sorting and accessing of information concerning the many aspects covered by these three areas. They are intended to be used by the ECCO during retasking mission planning as guides to the overall objectives and the limiting constraints.

52

Appendix C: Hook Book

Introduction

The purpose of a Hook Book is to gather thoughts, needs, criticisms, recommendations, and various other inputs over time so that basic trends can be determined. This is possible because the realization of a need, or an idea of how to solve a problem, or the realization of the core of a problem, for example, will surface repeatedly over time. The problem is that these realizations will take on many different manifestations due to the specific subject being addressed at the moment or the specific stimulus that triggers the thoughts. Additionally, due to the time and number of events happening between the occurrence of like ideas, it is difficult for an individual to mentally track the development of a pattern or trend. These apparently random and unrelated thoughts therefore can ultimately be grouped and filtered into coherent associations of ideas only if gathered in a systematic manner and only if viewed over a period of time, such as three months. This will point out those major areas of concern, maturing ideas, long term needs, and any number of other subject areas.

The identification of future needs and the directions of future expansion are key elements in the adaptive design process. The use of the hook book therefore becomes crucial to the process of adaptive design by more clearly defining these future needs and directions of expansion. Specific areas of interest that were tracked during this research were:

1) The use of a computer-based approach for the storyboarding process,

2) Future research for the specific DSS,

3) Ideas on the impact of the DSS,

4) Adaptive design,

5) The user development of storyboards.

A technique using note cards to record ideas as they occurred was employed in this research as the hook book. The note card based hook book had a specific format which required the notation of:

1) The thought or information,

2) The general subject area or title of the thoughts/information,

3) The date on which the notation was made,

4) The circumstances which triggered the thought are also noted so that a reference or framework can be established for the thought (43).

Recording thoughts and other information in this manner allowed the later determination of trends over time. The format of each subject area in this appendix follows this same chronological arrangement to show the reader the same development of ideas over time and how the various conclusions in Chapter Four were arrived at.

Three major areas developed as a result of using a hook book and tracking the thoughts and realizations that occurred over the period of this research. These three areas of ideas establish the major sections of this appendix:

1) Organizational Impact,

2) Decision Support Systems and the Adaptive Design Process,

3) The ECCO DSS and Its environment.

Organizational Impact

It is the opinion of former USAF Chief of Staff General Welsh that the value of optimization techniques to aid in the command and control of war is generally questionable. This is due to the fact that war is inherently wasteful and the margins of error are very gross while optimizing control or efficiency is concerned with making finely defined and constrained choices at the margins (48).

While gross margins of error are obviously true in the general conduct of war, in the area of electronic combat the margins of victory or defeat are more tightly defined, as in the few seconds of delay in the actions of an opponent to engage friendly attacking forces. The better able an organization is at adapting its EC packages to the changing environment and optimizing their effectiveness against an opponent, the greater the possibility of mission success. Even so, what other impact will a DSS have on an organization at the same time it is increasing its effectiveness? In answer, this section is divided into five parts to discuss issues in the following areas:

1) Command/Mission Impact

2) Command Structure Impact

3) TACS Capability/Structure

4) Use of Expert Systems (AI) in DSS

5) Miscellaneous

Command / Mission Impact.

1) 8 AUG 87: COMMAND AIDING: Though the concept of aiding the mission planning process (force and unit levels) appears to be well on its way, HOW DO YOU AID THE CC (commander) DURING MISSION EMPLOYMENT? CAN THE FORCE CC IMPACT THE MISSION VERY

MUCH ONCE THE MISSION IS OVER THE LD (line of departure) AND INTO THE FRAY? While it appears that if these decisions can be made and executed quickly enough then this can be done by trading between packages, it isn't clear that this would be a good idea once the units are already or nearly ready to execute final actions. , such as entry into the target area.

2) - --- --: IMPACT ON OPERATIONS: How does speeding up the planning/decision making process impact the organization? In general (all things working in theory(!)) this will allow the commander to take the initiative, take advantage of opportunities, be FLEXIBLE.

3) 20 JAN 88: IMPACT ON OPERATIONS: Due to the near equality of forces (on a front such as NATO - WP front), only way to beat the enemy is flexibility, BUT if the idea of retasking is anathema in many operational agencies how can we be flexible? How do we exercise the concepts of Mass (concentration) of Force, of Maneuver, of Economy of Force?

4) 2 FEB 88: LIMIT OF AID USEFULNESS: There is a point in a mission that a crew CAN NOT respond to redirection (regardless of the capability to get them the needed information and reconfigure the aircraft) without putting themselves and others in greater peril than if they just follow through with the mission. THEREFORE, will the introduction of a real-time retasking DSS lead to the command structure trying to retask after some N0-CAN-DO point and thereby cause greater loss and problems than it will solve? How can this point be determined with any reliability?

5) 25 FEB 88: AID USEFULNESS AND ORIENTATION: Do we want to aid the <u>mission</u> employment of assets even if we can? Why even bother to ask this question? Even if there are the systems to overcome all the input and execution problems, the commander is limited, in terms of time, in his ability to complete the decision cycle and the crew is similarly limited in their ability to react to

command retasking even if they are given the correct information. Also, there is a point past which a change will create greater problems and cause greater loss than following through with the original mission or giving the crews a NO GO due to the fact that the attack they are supporting has been cancelled. THUS: real-time retasking CAN be used and DOES need to be developed (carefully), it seems the area to really concentrate in order to gain the greatest pay back by giving the commander flexibility would be reducing the sense/decision/execution cycle at the TACC/ATAF level down to the area of 3 to 6 hours. This would allow the commander to respond to operational level opportunities, which are generally of greater significance than tactical, while retasking could affect tactical efforts.

6) 2 MAR 88: COMMAND AIDING: There is a serious misuse of the of the EC-130 because AIR COMMANDERS DO NOT UNDERSTAND THE MISSION OF THE EC-130, HOW IT SHOULD BE EMPLOYED TO ACCOMPLISH ITS DOCTRINALLY DEFINED MISSION, AND THE TRUE IMPACT OF THAT MISSION ON THE POTENTIAL FOR THE SUCCESS OF FRIENDLY FORCES. To assure the proper use of the EC-130 as well as other forces, any decision aid such as the ECCO DSS should have extensive memory aids on equipment specific capabilities, doctrine, limitations, and so on. This may help improve the employment of individual systems and thereby increased effectiveness of the overall force.

The upshot of these previous entries are that retasking can be a valuable tool within recognized confines but it may not be the place to center the greatest efforts for flexible force command due to mainly human limitations (at least while there is a human is still flying the aircraft and the role of "pilot" has not yet been assumed by remotely piloted vehicles). Retasking may be constrained due to the limited time in which a retasking decision must be made, communicated, and executed in theaters like NATO or Korea and the time required for humans to digest even the best information and act on it. The greater usefulness, and therefore greater pay off, may be the command decision cycle that culminates in the generation of the ATO and its execution. Decreasing this latter cycle to three to six hours would allow the air component commander to mould the theater tactical and operational battles while leaving the aircraft tactical battles to be fought by the crews. History testifies to the soundness of individual aircraft combat tactics but is less convincing as to the strength of higher levels concepts. This would include such areas as the coordinated employment of EC assets in support of task force level operations. All levels of combat must be won to win the war as well as the battle. Consequently, the responsiveness of the command cycle at the theater tactical/operational level appears to be the area of greatest pay off and consequently the area to focus on first with retasking as a parallel but slightly lower priority.

Command Structure Impact.

1) 23 SEPT 87: COMMAND LOCATION: Where do you put the command point for the C2 of EC assets? Due to the scarcity of EC assets, the commander only has the flexible tactical/operational control (terms used in the sense of tactical-operational-strategic) necessary to take advantage of opportunities and react to enemy threats at the theater level. Therefore, C2 of EC assets must be at the theater or AAFCE level. PROBLEM: AAFCE works the strategic level/allocation of resources and NOT the current battle. HOW MIX?

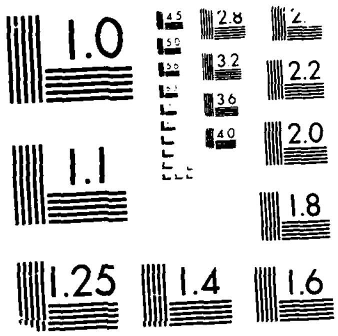
2) 23 SEPT 87: COMMAND LOCATION: In constructing the C2 structure, where do you put the control? ABCCC (Airborne Command and Control Center) for its LOS (line of sight) capability? Borefink? ATAF? ATOC?

3) 24 SEPT 87: OBJECTIVES: Tasking and therefore retasking MUST be in line with the Air Commander's objectives which are in turn supporting the Ground Commander's objectives.

4) 25 SEPT 87: COMMAND LOCATION: The ABCCC works the air-ground mission areas, AWACS works the air-air mission areas.

AD-A190 762 DESIGN REQUIREMENTS FOR A DECISION SUPPORT SYSTEM FOR THE DYNAMIC RETASKI (U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF ENGI C D FLETCHER 3/3

UNCLASSIFIED MAR 88 AFIT/GST/ENS/88M-3 F/G 25/5 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

Given these divisions, the ECCO should go on ABCCC if he is to be put into the air (with consideration of operating world wide, position should be in air as well as on ground for NATO as this results in the system being redundant and survivable).

5) 25 SEPT 87: COMMAND LOCATION: Who should have authority of this very scarce asset? Must support overall goals of theater commander and therefore be able to shift EC assets across command lines within theater (example: NATO) and yet be in position to monitor/execute tactical operations. For operations outside of NATO this does not appear to be a problem as is only a single air forces commander whereas in NATO is several ATAFs where may need to shift forces among these and this must be done by an authority with a broader view than a single ATAF commander.

It would seem that in theaters where there is only a single air force component commander that the question of where to position the ECCO is not really a problem. In NATO, with its multiple ATAF commanders each tasked with responsibilities, there is a problem of shifting assets among the ATAFs because it is not likely that one commander, hard pressed with what he does have, is going to freely and quickly release operational control of assets. In NATO this is a political as well as military problem.

TACS Capability / Structure.

1) 23 SEPT 87: C2 RESTRUCTURING: To accomplish retasking the C2 structure must be changed to support:

- How do you determine that there is a problem and communicate with EC assets? INPUT: real-time intelligence feeds, JTIDS communications with forces PROCESS: filter information through threshold triggers to check for problems such as loss of forces or unexpected increases in threat level.

- How advise commander as to better/best way to use assets? Use of DSS should enable the analysis of user-developed alternatives to determine better ways of using EC assets under a changing environment.

- How do you redefine airspace/ADA status to enable the dynamic use of EC assets? Requires a rapid, secure, fully integrated joint/combined communications capability. The current manifestation of JTIDS is an initial step in the direction of accomplishing such an objective.

- How do you give airborne crews a new mission so that they can execute it with as great a potential for success as if it had been planned under the normal planning process? Requires that the crew have all route, communications, coordination, and target information to include route/ target area/target study. Again, JTIDS is an initial step toward this and will be even more applicable with the preplanned improvement which allows the in-flight modification of the displayed routes and boundaries. This does not address getting the crew the type of route and target/target area study needed to determine crew/team/unit tactics and the preflight coordination among crews necessary to execute those tactics. While JTIDS may again be able to give the communication capabilities needed to overcome these hurdles, there is a very real question as to whether or not there will be the time to do all this coordination (18; 23).

- How do you reconfigure an asset's on-board EC equipment/ weapons/expendables for a retasked mission OR does this become a planning constraint for retasking?

- How do you assess the potential for EC/hard kill fratricide and then coordinate to minimize it?

2) 24 SEPT 87: C2 REQUIREMENTS: JTIDS offers solution to the need of a secure, high data rate communications capability BUT is it built with reliability/survivability and is there a second system

(backup, redundant) with the same characteristics? If there isn't a "backup JTIDS," what capability do we have to operate without it?

The impact of these thoughts are that the ECCO DSS is worthless without these kinds of TACS modifications to give the commander the capability to do retasking. Similarly, if retasking is to be pursued and the types of system changes as mentioned above are instituted, then it is absolutely critical that something like the ECCO DSS be planned for and constructed so as to enable the commander's staff to generate intelligent plans and options for the commander to consider as needed.

<u>Use of Expert Systems (AI) in DSS.</u>

1) 8 NOV 87: USER ACCEPTANCE: Will users accept DSS determinations/conclusions/recommendations? The DSS must have the capacity to explain those things which are derived conclusions and more than just complicated number crunching (For example: Though a route looks good with the critical IADS nodes destroyed, route Pk is shown as 0.58. WHY? The route overflies the general assembly area of a armored division with its heavily reinforced air defense units and the terrain is composed of open stretches of flat terrain giving the mobile SA-6/-8/-etc.s very good chances of successfully utilizing their full capability for autonomous acquisition and engagement.).

2) 8 NOV 87: IMPLICATIONS: DOES VERY USE OF EXPERT SYSTEM ERODE HUMAN EXPERTISE DEVELOPMENT even while explanation capability of AI system may win user acceptance? Does human user understand WHY the particular rules where chosen and fired in the order they were fired in if he hasn't spent time "in the dirt" to find out for himself? OR will AI allow for the building of further expertise on an AI expert system foundation?

3) 10 FEB 88: IMPLICATIONS: If DSS and/or expert system is fully accepted by a unit, what is the effect on the units ability to

operate/survive if the system(s) goes down? How does this affect the ability of people to gain their own experience to gain insight on a problem and develop their own thoughts on a subject (30; 41).

These are areas of great concern as it is very important that the operation of those systems be understood so as to fully utilize their potential. Also, the complete understanding of these systems is of even greater importance when the systems are lost due to battle damage and the C2 system must once again fall back on human operators. This is an area for further, basic research.

Miscellaneous (but Important).

1) 29 SEPT 87: OPERATIONS IMPACT: What are the effects on a coordinated operation and the commander's ability to successfully pursue the battle if the DSS is down due to hasty movement (planned movement should include the operation of an alternate system)? Due to destruction? The answer to this question helps establish the system's value and therefore the level of means appropriate to keep it in operation.

2) 18 NOV 87: MANAGEMENT OF ADAPTIVE DESIGN: How does "the system" (the USAF support system) manage the development and support of an adaptively designed system? Adaptive design should be done on site with the users BUT if the system is used throughout the Air Force (i.e., world wide) and in a variety of specific applications, then WHO decides WHAT changes will be implemented WHEN?

Proposal for implementation: User submits a desired change to a local DSS referee who sits at no higher level than the directorate above the unit (flying squadron submits request to DO referee). The referee is a former user of the systems and can see their use across the other unit of the directorate within the wing. The directorate referee is on-line with other wing-level referees who evaluate the suggestion and submit it up to command headquarters for review and approval before recommendation to the AFSC/AFLC OPR. This evaluation requires that support and integration of the system be considered. To be responsive there is a 45 day time limit on this process. PROBLEMS: This introduces another tremendous (and generally unwanted/unneeded) bureaucracy into the military. The momentum toward standardization would nullify the advantage of adaptive design which is the direct implementation of a system tailored to that specific user's/unit's needs. Standardization would leave the user with a system that was a compromise of the needs of all other units. With the world-wide mission of the Air Force and its requirement for personnel interchangeability, is this compromise not inevitable? PROPOSAL: The Air Force might adopt the philosophy of portability, borrowed from the field of computer science, to avoid undesirable compromise, make the adaptive design process workable, and retain the advantages of a system responsive to the needs of the LOCAL user. Portability first provides a core structure which is standard throughout the Air Force and controlled at the Air Force level. This core then supports the unique capabilities of a command or theater by the addition of a layer external to the core. This additional layer is controlled by the particular command or theater it was built to support. Finally, this command-customized system supports further customization by individual units to do the unique job these units have been assigned to accomplish.

3) 12 JAN 88: DYNAMIC RECONFIGURATION: How can required in-flight reconfiguration of mission assets be accomplished?

DSS and the Adaptive Design Process

This second, more theoretically oriented, section is divided into the the following four parts:

1) Capturing User Input,

2) Adaptive DSS Design,

3) Follow - on Research: General,

4) DSS Evaluation of Operations.

Capturing User Input. The user and his/her organization are the best source for generating the requirements for whatever support systems they may need to accomplish the tasks they have been given. Consequently, the capture of this information becomes very important. As mentioned previously in this thesis, past efforts have shown that the one-time questioning of users as to their needs, and other similar techniques, generally leads to unsatisfactory results. Additional research, also previously mentioned, has shown that data gathered over time enables the establishment of truer basic needs by overcoming problems of human perception like remembering yesterday's problem instead of the problem that continually reoccurs. The question then becomes how to gather this information while interfering the least with the user's job at hand and retaining the context of the problem.

1) 27 AUG 87: REQUIREMENTS CAPTURE: Need to allow user ideas/complaints/recommendations/etc. to be noted with minimal cognitive interruption of current task. HOW? Might use light boom mike on head set with foot mike to allow user to "think out loud." Could also hook up to DSS for audio prompts and other information (22).

2) 8 NOV 87: SYSTEM ENVIRONMENT: Use of HyperCard-like environment (An environment links the tools, capabilities, data, and models of a system) - Build the DSS so that the user can't change the system permanently but give the user the ability to duplicate panels and then change/write on the duplicates to show what is desired. OR/AND - allow the user to make a temporary change to the operating system by inserting the changed "card" or commanding a

system change. These effects would be deleted on command or on turning the system off or on resetting the system.

3) 18 NOV 87: SYSTEM ENVIRONMENT: Use a HyperCard-like environment in an operational system to pull in and run operations (models, data bases, spread sheets, etc.) - USER enabled to take snap-shot of screen and modify, write on, etc. and send off to store for later evaluation.

4) 18 NOV 87: SYSTEM ENVIRONMENT: It would be best to have a software environment which supports a full-up operation as well as storyboards/functional display. This would then allow the evolution of a system from storyboards to operating system, the direct comparison of the desired system versus the delivered system, and allow the creation of storyboards from the current operational system to annotate desired changes.

5) 18 NOV 87: REQUIREMENTS CAPTURE: Snap-shot of screen used to capture user requirements should automatically be annotated with the date and time, the ability for the user to link to other cards to show a desired sequencing, and a place to indicate how badly a change is needed (this last area would have to be filtered, or ranked, later in view of all other needs using a process such as an Analytical Hierarchy Process).

6) 15 DEC 87: REQUIREMENTS CAPTURE: How can user input concerning needed systems evolution be obtained with minimum impact on the current thought process which generated the desire? For this DSS try: (1) When user hits the HOOK BOOK button, the system automatically takes a snap shot of the screen (2) and, in a separate storage area, presents the picture of the screen with an open text field and graphic tools to use for making notes and changing the presentation. (3) The system automatically records the date/time, user, and other information required to reestablish the context of the original comments. (4) A RETURN button to take the user immediately back to the point where he was when he left.

7) 5 JAN 88: STORYBOARD DEVELOPMENT / REQUIREMENTS CAPTURE: Any system is very time intensive for the user if storyboards must be developed from SCRATCH; BUT, if there is a library of "building block" parts/icons available to build new screens then the user can build a screen or screens fairly quickly and show them to a designer. THUS, a ready library would ease use of the system and thereby encourage the use of a system to build storyboards and decrease user construction time. The storyboards would provide a ready and well-defined basis for user-designer communications and thereby hopefully result in decreased miscommunications between the builder and user.

8) 23 FEB 88: USER STORYBOARDING: CAN a user use the storyboarding process? Will a user WANT to use the process? Would a HyperCard-like environment be acceptable to a user for storyboarding? A user can do storyboarding and will use the process if it results in getting better tools to do his job. Therefore, a user will use storyboarding IF the storyboarding process is easier and quicker than the process currently possible. To meet these goals, a user must be given a library of frames and icons close to what is needed to quickly build a needed representation AND an easy, very "user friendly" application to support the building of storyboards. This library might be developed by the designer/builder based on initial conversations with the user during the initial research of the problem. The HyperCard environment is very easy to use and would supply a dynamic dimension to a user developed storyboard. It might be used if the initial storyboard construction was easier. Regardless of whether the storyboards are actually constructed by the user or the designer/builder, the user should be intimately involved with the construction process. This is because storyboarding requires a thorough analysis of the process to be aided which in turn often results in valuable insights into the aided process.

Adaptive DSS Design. The process of adaptive design is encapsulate by the phrase "start small and grow." The small starting point is the kernel. One way to choose the kernel is through the use of concept maps. Concept maps will show the relations between the various ideas and functions that make up a process and from these component parts a subprocess can be selected to be the starting point or kernel of the ultimately complete system. The designer/builder can implement this subprocess using the concept map as an initial cut at bounding process. Fine definition of the bounds occurs during the storyboarding process. Staying within the bounds is not easy.

1) 12 FEB 88: CONCEPT MAPS AND DSS DESIGN / CONSTRUCTION: It is very difficult to stay within the confines of a single kernel when trying to design and/or implement the first parts of a DSS. This seems to be due to the extensive amount of interrelated/overlapping information that is shared with other kernels of the DSS which results in the designer/builder quickly finding themselves working in other than originally intended areas. This defeats the purpose of kernel implementation if the system is not contained within the original bounds because it slows the system's development/ fielding. Additionally, the designer/builder finds himself quickly overwhelmed by the size of the more complete system. This problem might be avoided by turning the concept map of the kernel into a guidebook in the form of a checklist (?) and referring to it often, possibly checking off those areas that have been completed and confirming what is needed next.

Follow - on Research: General. Many of the comments and suggestions made throughout this thesis and appendix will require further study and research. The areas commented on in this section are not easily categorized to one of the foregoing sections but are very pertinent to both the ECCO DSS as well as to systems beyond the ECCO DSS.

1) 20 AUG 87: ALTERNATIVE GENERATION: The DSS needs to incorporate an ACTIVE ALTERNATIVE suggestion capability initiated by the machine.

2) 27 AUG 87: ALTERNATIVE GENERATION: How does the DSS aid the user in the area of alternative generation? May be able to use a library of war-game developed ideas/scenarios in a relational data base. This would enable the filtering of the many scenarios based on the needs of the user at the time.

3) -- --- 88: ALTERNATIVE GENERATION: Under situations of high time stress, might want to have available to the DSS prestructured ("canned") alternative templates (concept of templates borrowed from cognitive sciences and the field of Artificial Science) (17:951). These could be keyed by solution drivers which would generally mean the constraints of the problem such as the number and mix of the EC assets. A decision tree could be set up based on the type of aircraft for the decision tree level and the number of that type aircraft being the different possible branches. At the end of the branching, which represents the current combination of aircraft, there could be a set of plans which are themselves differentiated by the threat environment and mission. Therefore, the number of mission templates would equal at least the number of possible threat environments, n, multiplied by the number of missions, m. Beyond this number, it would be best to have two or three plans for each threat-mission combination, each addressing other key mission aspects. This would lead to a total number of 3 * m * n * (the number of aircraft combinations).

<u>DSS Evaluation of Operations.</u> It is a matter of the utmost faith (and definition) within the field of Operations Research that a process/problem can be modeled and thereby quantitatively measured using one or several of the many purely quantitative and pseudo-quantitative tools available for the purpose of achieving optimal decision making (16:6). Some processes are more difficult to measure or evaluate than others due primarily to a lack of

understanding of the full details of the process's interactions. One of these processes is war of which EC is a subset.

1) 24 SEP 87: ALTERNATIVE VALUATION: How do you value EC assets and assess their impact on the environment so as to measure one plan's value and comparative ranking over another plan?

2) 29 SEP 87: IMPACT MEASUREMENT: Initial Cut - Given the commander's objectives, a gross idea is needed of the combined worth of the planned attack force's capabilities, the worth of individual force components, the value of its limitations, the worth of mission roles in contributing to the mission objective, environment, and the worth each subportion to the overall mission (i.e., what is the worth of hitting a specific GCI site in a highly redundant, overlapping, and interconnected GCI system to the outcome of the mission as versus the risk and impact on future missions of exposing the assets to the threat environment in supporting the strike against that GCI site? If the assets were to have been exposed to threats in their original tasking, then the subsequent exposure to a threat environment under retasking is not a change ("sunk cost") and therefore is not a valid criteria. The new criteria might be the difference between the worth of the originally tasked air forces versus their increased worth as a result of reduced attrition due to augmentation by EC forces.). A JMEMs (Joint Munitions Effectiveness Manuals) style data source is needed which would provide EC information and known capabilities against various individual targets and combinations of targets (6). This would be an initial step in developing this measurement capability, allow for the comparison of forces versus targets, give planners the ability to do measured trade offs, and help establish target inherent worth both from the aspect of the target's system worth and cost to friendly forces.

3) -- --- 88: VALUATION CAPABILITY (A SURROGATE MEASURE OF A C2 SYSTEM): A capability to evaluate the loss of friendly assets versus enemy damage is needed. This could be used as a

measure of a C2 system by measuring the difference between the kill ratios of a C2 system using a modification of interest and a C2 system not using the modification.

To choose between alternatives there must be a basis of comparison. This is a field that has still to be satisfactorily addressed within the area of warfare and especially within both the fields of electronic combat and command and control. Serious and concentrated research is still badly needed in these areas.

The ECCO DSS and Its Environment

The question of retasking is a large and very complex one. In working through the development of the ECCO DSS there was the constant requirement to focus on a tightly defined area and note requirements for work in other areas. The following four parts are the result these observations and constitute the divisions of this section of the appendix:

1) Degraded Operations,

2) DSS Improvements,

3) Adaptive Design of the ECCO DSS: Future Areas for Evolution,

4) Deconfliction.

Degraded Operations. Any system fielded to operate in a warfighting environment must be able to operate and accomplish its design function under the most adverse conditions. This environment is unique in that the system.itself is being actively targeted for destruction. Consequently, the system, whatever type of system it may be, must be able to function even while damaged.

1) 21 AUG 87: DEGRADED OPERATIONS: Some work needs to be done to address how the DSS will operate in a degraded mode due to loss of intelligence inputs, how to prevent the loss of these inputs, the possibility of minimizing the impact of losing information input by ensuring that other systems throughout the C2 system have some capability to reproduce various aspects of the functions of the ECCO DSS.

2) 22 AUG 87: DEGRADED OPERATIONS: The impact of degraded operations can possibly be somewhat ameliorated through the continual sharing of information between command centers and systems, the use of common, shared data bases, and overlapping functionality of fielded systems to enable one or more systems to replace the loss of another system.

3) 2 FEB 88: DEGRADED OPERATIONS: Throughout the operation of the system snapshots of data and presentations are stored, primarily to allow the historical representation of the war but also to accomplish operations if the input source goes down. This stored information can be used to PROJECT enemy movement with an ASSOCIATED CONFIDENCE LEVEL. This confidence level on the information being presented will change as a function of time. Updates of this information will restore the confidence level but the confidence level will immediately continue to decay after the update.

4) 13 FEB 88: DEGRADED OPERATIONS: What happens when the input link showing the current EOB (Electronic Order of Battle) goes down? It may be possible to use the last or best resent (information with the highest available confidence level within the last three hours) available information of the EOB with historically based state vectors to show where depicted units are headed. These would also have an associated confidence level which is time dependent. After a sufficient amount of time has elapsed so that the confidence level is unacceptable then the system shifts to using updates, such as crew debriefs, in conjunction with enemy doctrinal template models to project courses of action.

There are a myriad of other aspects to the problem of degraded operations of combat operations systems that must be addressed as well as the few mentioned here. In the consideration of this specific system it quickly becomes obvious that it is very reliant on intelligence input information. It is also obvious that the cessation of this information could result in just so much metal and so many computer chips sitting around taking up space and leaving the commander worse off than before the system was introduced. Consequently, the problem of how to assure the continued useful operation of this or any other C2 DSS that relies on external information input is very important. The use of historically based trends in enemy actions to be used as the initial input for models used to project continued enemy actions may be one way of addressing the problem.

DSS Improvements. This section addresses improvements necessary to the operation of the ECCO DSS besides those obvious improvements of the ECCO DSS due to its expansion to serve in the many other areas cited in the concept maps.

1) -- --- --: JOINT / COMBINED OPERATIONS: Above all else the DSS should be cooperatively expanded to include the capability to handle all US armed forces EC assets as well as all allied EC assets. This should be done even before the completion of the DSS to handle all aspects of the current three systems for at least two reasons; (1) A cooperative effort would represent a "political" acceptance within the services of the need for truly integrated operations, and (2) The planned integration of other assets would insure that data bases, models, and control mechanisms are kept flexible enough to handle the later inclusion of these systems.

2) -- AUG 87: GENERAL CHARACTERISTICS: DSS elements must have TRAINING/EXERCISE/DIAGNOSTIC capabilities embedded. This overcomes the cost of constructing additional training facilities as well as the loss of realism.

3) -- AUG 87: DISPLAY REQUIREMENTS: Need to enhance presentations by enabling the display of range rings, "time-to-go" rings for selected systems, allow the selection of geographic orientation, enable the display of azimuth and range between selected objects, and the use color (in a consistent manner).

4) 29 SEP 87: EC PLANNING MEMORY AID: Need operational planning aid to give general information on different EC systems such as mission roles, capabilities, limitations, notes on interaction with other systems, and other pertinent data. Also, the system should have the capability to display similar information on specific assets in the air, such as its equipment/ ordinance configuration, fuel state, and other pieces of information needed by the ECCO for planning alternate missions.

5) 24 NOV 87: AIR MANAGEMENT: Enable DSS to determine if the transfer of assets between two attack groups is feasible based on time and system capabilities. Give the operator an explanation of why a transfer is not feasible and a checklist as a memory aid if the transfer is feasible.

6) 9 DEC 87: IADS TRENDS: Enable the time sequence display of the IADS to show trends in effectiveness, operations, enemy intentions, goals, as well as information on other subjects.

7) 12 JAN 88: PLANNING MEMORY AID: For each aircraft (when SHOW VECTOR selected) show: (1) Graphic time/speed vector to give a feel for aircraft velocity relations (2) Range ring which is a function of the aircraft's fuel state and current speed or a selected speed (3) Maximum operational range ring which shows how far an aircraft can go, given a selected mission profile and whether or not combat tactics will be used, and still return to the planned landing base.

8) 18 JAN 88: MODELS: DSS models which compute jamming effects must take into account types/techniques of the jamming and the

victim radar, polarization, range and power distribution, terrain influence, weather influence, and other factors such as the changing radar cross section of the aircraft.

9) 28 JAN 88: COMMANDER'S GUIDANCE MEMORY AID: DSS should have "CC GUIDE" button which when selected would show;

(1) A map overview of the area with the stated geographical objectives and associated targets,

(2) A graphic representation of the allocation and allotment break down,

(3) An aggregate depiction, keyed to the current area of coverage, of the major air thrusts, objectives and goals,

(4) A listing of the commander's guidance.

Adaptive Design of the ECCO DSS: Future Areas for Evolution. The ECCO DSS must incorporate various capabilities represented in the concept maps of Appendix A but not yet designed into the storyboard strawman which was shown to the users as represented by the 507 TACC. Areas that will need to be included or studied further before inclusion are discussed in this section. There are also included some thoughts concerning the impact of the adaptive design process on the USAF.

1) 8 AUG 87: COORDINATED ASSESSMENT: A DSS that uses multiple cooperative models which provide information to each other to come up with an evaluation must all be based on the same assumptions, constraints, logic, resolution, tactics, assessment of the threat systems, the threats' C2 system, the effects of friendly countermeasures on the threat, as well as use the same algorithms. This coordination of the models will help lead to results that are at least consistent (these problems should be addressed in the establishment of a service-wide management system to implement

and maintain a hierarchy of models). Otherwise, the same questions and input will yield different output.

2) 23 SEP 87: IADS: The DSS needs to be able to assist in answering the question of what level to knock the IADS down to so as to realize minimum attrition for a given mission. To do this, the DSS needs to be able to display the IADS C2 interconnectivity, indicate the type of interconnectivity (data link, hard wire, HF/VHF radio, etc.), display the critical nodes, indicate the current operational level of a unit (such as Independent, Semi-Autonomous, etc.), and be able to account for the change in friendly attrition due to these effects and operational levels. ADDITIONALLY, the DSS must also address the SILENT THREAT (31). Is a threat system silent because it has been killed? Then actively targeting it is a waste of resources. Or is a threat system silent because it is waiting in ambush? How can this be determined and indicated?

3) 23 SEP 87: EXPENDABLE EC ASSETS: The use of EC assets, such as TACIT RAINBOW, must be considered in a C2 problem. QUESTION: Has the C2 and employment doctrine for these systems been developed? Has the impact on current doctrine been considered? These questions are critical because they will dictate how the ECCO advises the commander on the use of these and other EC assets.

4) 23 SEP 87: MODELLING AN EC ENGAGEMENT: How is it known when to initiate jamming of the model aircraft against any given threat? This will impact the outcome of the modelled engagement and eventually the analysis of the alternative plans.

5) 29 SEP 87: SYNERGISTIC EFFECTS: How can the interactive/synergistic effects of electronic combat be predicted and/or planned for (6)? Do you want to plan for these effects? Planning for positive benefits from these effects would lead to planning a best case scenario. Planning on negative benefits from these effects would lead to planning a worst case scenario. Each type

of benefit could cause a significant variation in the support configuration.

6) 29 SEP 87: PLANNING MEMORY AID: A DSS should have a JMEMs type capability for EC planning. There needs to be the capability to compare friendly EC capabilities against adversary systems, friendly vulnerabilities against adversary systems, remind the ECCO as to the appropriate mission role of assets, and determine friendly EC optimal support configurations to support the attack force.

7) 29 SEP 87: ENEMY REACTION: It is important to future planning to be able to determine changes in enemy capabilities due to EC actions as well as enemy reactions and how those reactions change over time (6). This knowledge would point up enemy vulnerabilities and give indications as to how long the enemy systems might remain vulnerable before corrective action closed that option to friendly planners.

8) 8 NOV 87: WARNING OF UNACCEPTABLE PLAN CHANGES: How does a DSS warn the user that a change has occurred in the plan that requires either initiating an alternate plan or starting the retasking process? The DSS can be loaded with a copy of the mission plans which can be used to compare with real-time information of the actual missions. Threshold differences can be set for various aspects of a mission and when the difference between the planned and actual mission becomes greater than one of these thresholds then the system automatically triggers an alarm for the operator. These threshold should be set for areas such as course deviation, timing, force composition, attrition levels, and other items. Additionally, these thresholds should be area selectable and user defined.

9) 8 JAN 88: UNCERTAINTY: How can/should uncertainty/variance/ confidence be indicated for both the input information (intelligence) and the analysis results? Does a planner need to know this

information? Will this type of information have an impact on retasking?

10) 20 JAN 88: CURRENT POTENTIAL: Due to the complexity of the ECCO DSS, it may not be possible to field a system that is able to accomplish both the capability requirements and the speed/time requirements. If not, it might be necessary to first field a system that uses a 'Rule-of-Thumb" approach.

<u>Deconfliction.</u> The requirement to deconflict both physical and electromagnetic space is just the logical extension of a commander's need to conserve his forces. The extreme complexity of a large military operation may render current attempts at perfect deconfliction completely ineffective and laughable. Deconfliction is probably a misnomer more properly termed Conflict Management.

1) 29 SEP 87: DECONFLICTION: For the purposes of conserving forces, gathering the best possible intelligence, and assuring the best possible coordination of force effects, the DSS should be enable the management of (1) the coordination between combat EC requirements and intelligence ELINT taskings, (2) the EC efforts on the ground as well as in the air, (3) the coordination of EC timing, and (4) ingress/egress air space.

2) 9 DEC 87: AIR SPACE DECONFLICTION: How should airspace management/deconfliction be depicted for the purpose of transferring retasked forces? Should it be completely a computer check of possible conflicts with other current or planned operations or a combined computer and visual depiction check? The process could be as follows;

(1) Currently active routes and those ATO planned routes that will be active during the projected retasking would be overlaid on the overview display,

(2) The proposed route(s) would then be overlaid on the overview display,

(3) The system would simulate the plan and do a point by point evaluation of the proposed routes to check for conflicts in both time and altitude,

(4) Real world flight activities do not arrive at points exactly as planned but instead arrive with some amount of error in their arrival times as compared to their planned arrival time. The same is true with respect to altitude. Consequently, "conflict" in planning could be defined as whenever two aircraft/forces come within two sigma, or two times the.standard deviation from their mean arrival time/altitude, of each other in terms of either altitude or time. These could be differentiated by color. The conflict could be coded red if the conflict was within one sigma for both forces. It could be coded orange if the interaction was within one sigma for only one force and between one and two sigma for the other force. The conflict could be coded yellow of the conflict was between one and two sigma for both forces.

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Major Charles D. Fletcher was born on 25 February 1953 in Stuttgart, West Germany, while his parents were stationed there with the US Army. He received his Bachelor of Arts degree in History from the University of Florida in 1976. Upon graduation, he received his commission in the USAF through the ROTC program. He was called to active duty in September 1976 and assigned to Mather AFB, CA, for instruction in the Undergraduate Navigator Training and Electronic Warfare Training programs from which he graduated in December, 1977. After completing B-52 Electronic Warfare Officer (EWO) training, he reported for duty with the 2nd Bombardment Squadron (Heavy) at March AFB, CA, in June, 1978. While assigned to the 2 BMS, he acted as the 22nd Bomb Wing (BMW) Chief of Operations (detached-England) for B-52 conventional operations supporting NATO exercises and earned his maintenance AFSC. In 1982 he was assigned to the 320 BMS, 93 BMW, Mather AFB, CA, as a B-52 Instructor Electronic Warfare Officer for the training of initial qualification B-52 EWOs. In 1984 he was assigned to the 93 BMW B-52 Weapon Systems Trainer (WST) where he helped evaluate SAC's first fully interactive crew simulator, train WST instructors for the command, and headed an interdisciplinary team of Air Force and contractor personnel working the one million dollar program to update/upgrade SAC's WST threat simulation. In August 1986 he entered the School of Engineering, Air Force Institute of Technology. His follow-on assignment is Headquarters, Strategic Air Command, the office of Plans and Programs, HQ SAC/XPPD, (AV) 271-5391.

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The air commander's ability to shape and control the battle is just as critical for victory in the air as it is on the ground. The inability of the commander to control his forces in a timely manner will see them defeated by a more flexible opponent. Decision support systems (DSS) are a tool which can aid the commander by giving the overwhelming masses of information a structure for the decision process at hand and by aiding the evaluation of this information.

The problem of being inundated by data also applies to electronic combat (EC) assets. The commander's control of a these scarce resources requires a complex assessment of an enemy's air defense system and the determination of how to employ EC assets to gain the best degradation/destruction of those defenses.

To develope a DSS to aid the commander, the functions and requirements of the system must be established. The purpose of this thesis was to investigate the use of the storyboarding process as a vehicle for the establishment of systems requirements. The DSS focused on for this study was an aid to the Electronic Combat Coordination Officer (ECCO) for the dynamic retasking of airborne EC assets. The adaptive design process was used, therefore only a small core was initially proposed. The remainder of the system would follow as further requirements were generated.

The main objectives of this research were: (1) Model, through concept mapping, the probable decision process of the ECCO for the retasking of EC assets. (2) Continue the investigation into the effectiveness of paper-based storyboarding in determining system requirements. (3) Investigate the possibility of using a computer-based storyboarding process with the aim of determining the feasibility of user generation of system requirements.

The results indicate that the storyboarding process is excellent for the unambiguous communication of requirements. There is every indication that computer-based storyboarding can prove to be even more effective by taking the user one step closer to the actual system and may thereby enable the generation of system requirement by users in the field.

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